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References:

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Sahni, B. (1936a) Wegener's theory of continental drift in the light of Palaeobotanical evidence. *J. Indian bot. Soc.* 15: 31-32.

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J. Madras Univ., B. XXIX, No. 3, Pages 153-154, 1959.

A Note on *Eublemma versicolora* Wlk., a Webber on the Inflorescence of *Mangifera indica* in Madras State

BY

S. VENUGOPAL, M.Sc.

Entomology Section, Agricultural College, Coimbatore

(Received for publication on 4-7-59)

INTRODUCTION

Mango (*Mangifera indica*) is undoubtedly one of the most important fruit crops of India. It covers the largest area compared to any other fruit in this country and thrives almost in all regions except at latitudes above 3000 ft. The numerous varieties of mango cultivated in this country provide an unusual diversity of flavours and tastes and in many parts the mango serves as a staple article of food for several months in a year (Gangolly *et. al.*, 1957). The author during the course of investigations on the pests of mango inflorescence noted a webbing caterpillar doing considerable damage to flowers by constructing quite a number of silk lined galleries on the flower spike (Fig. 1). It was identified as *Eublemma versicolora* Wlk. belonging to the family Eustrotiinae. So far only three caterpillars namely, *Chloroclystis* sp., *Argyroploce aprobola* and *Eublemma angulifera* have been reported (Padmanabha Iyer, 1943) to do considerable damage to mango flowers. Since it is a newly recorded pest for the first time in Madras State on the mango flowers, a study was undertaken on the bionomics for the last three seasons and the results are presented below:—

Life-history: The female lays 8 to 10 reddish hemispherical eggs on the sepals of flower buds. The newly hatched larva is 2 mm. and emerges after an incubation period of 3 to 4 days. It is creamy yellow in colour and invades the buds and nibbles the outermost portion of sepals constructing a flimsy silken webbing. After six days, the larva migrates to the inflorescence branch and constructs a silken gallery overlaid by pellets of excreta. It even scrapes the green matter of the delicate branch and forms a tunnel and rests inside it with a covering of frass. It usually selects the

underside of the main or lateral shoot of the inflorescence and is seen to have a number of galleries made of silken threads and pellets of excreta. In the final stage of attack it has the tendency to become a borer into the side shoots. The full grown caterpillar is 20 mm. long and 6 mm. broad. The body is smooth, greenish yellow and changes to pink prior to pupation (Fig. 2a). The head portion is smaller than prothoracic region and has distinct light brown colour. The prothoracic shield is of the same colour as the head region. The body has sparsely covered hairs arising from whitish shining tubercles located on either side of the middorsal region. Prolegs are three pairs only, simulating a semilooper. The crochets are in uniordinal mesoseries. The full grown larva descends to the base of the inflorescence and constructs a fairly strong whitish silken cocoon with an outer coating of frass and excretory pellets and pupates in it (Fig. 3). The larval period lasts from 18 to 20 days. The pupa is cylindrical and dark brown in colour (Fig. 2b). The anal end is pointed and bears 2 small spines. The pupal period lasts about 8 to 9 days. The adult male is purplish pink or light orange with apical patch on the forewing. The female has the wings purplish grey and the underside brownish yellow irrorated with violet scales. The total life-cycle works out to 29 to 33 days. It invariably appears in a pest form during December to April at Coimbatore thus synchronising with the flower formation.

Insect association: This larva is invariably associated with the red tree ant *Oecophylla smaragdina*, Fb. It is a curious association conferring no benefit although it is reported to be predaceous on other insects.

Control: The pest is kept under check by the application of 0·1% spray of BHC or 0·1% spray of Aldrin.

Acknowledgments

The author wishes to thank Sri K. P. Ananthanarayanan, B.A. (Hons.), Retired Government Entomologist and to the present Entomologist for all the help rendered during the investigations.

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Padmanabha Iyer, K. S. 1943 "On three caterpillars destructive to mango flowers" *Indian J. Ent.* 5: 54-57.

Fig. 2.

Fig. 1. Fig. 3.

Fig. 1. Infestation by *Eublemma versicolora,* Wlk. larva on Mango inflorescence. Fig. 2. Full grown larva and pupa of *Eublemma versicolora,* Wlk. Fig. 3. Method of pupation of *Eublemma versicolora,* Wlk.

J. Madras Univ., B. XXIX, No. 3, Pages 155-181, 1959.

Fungi Isolated from Rhizosphere—V*

BY

V. Agnihothrudu **

University Botany Laboratory, Madras-5

(Received for publication on 23rd July, 1959)

In the fifth paper of this series are listed fifty species of *Fungi Imperfecti*, excluding the Penicillia, isolated by the writer during the period between 1950 and 1953 in the course of his studies on rhizosphere microflora of pigeon-pea (*Cajanus cajan* (L.) Millsp.) in relation to the soil-borne wilt caused by *Fusarium udum* Butler.

36. *Phoma* sp.

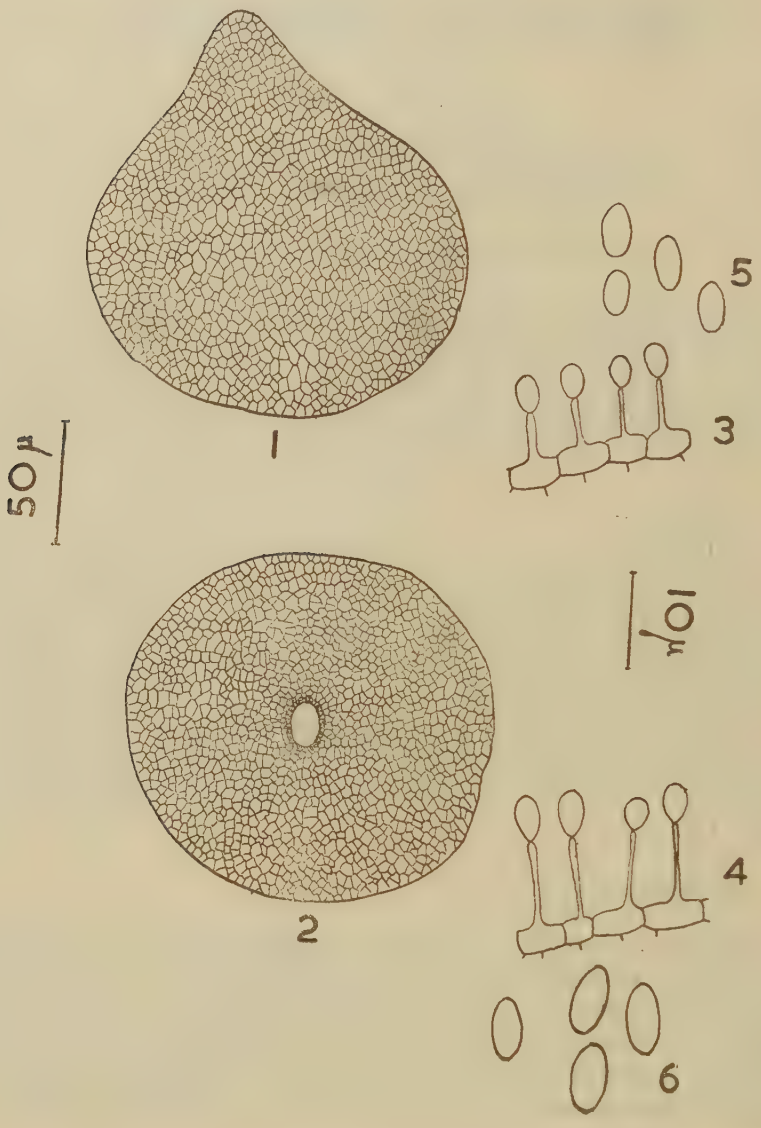
Mycelium hyaline first, becoming subhyaline to fuscous with aging, ramose, septate, 2 to 4 μ in diameter. Pycnidia are produced separately and sparsely on the medium, subhyaline, turning brownish, spherical, globose, lenticular or flask-shaped, typically ostiolate; sometimes the ostiole is elevated on a short papilla. Pycnidial wall membranous, made of polygonal cells, 3 to 4·4 μ in diameter, glabrous. Spores are ejected in long, coiling masses, typically oblong with obtuse apices, hyaline, 6·4 to 8 μ by 2 to 3 μ. (Figs. 1-6).

37. *Pyrenochaeta* sp.

Growth on potato dextrose agar restricted, adpressed; pycnidia are produced sparsely after 15 days; they are hyaline to subhyaline, becoming brownish with age, globose, conical, membranous. Pycnidial wall is composed of polygonal cells, fuscous in colour, provided with stiff unbranched setae at the ostiolar end. Pycnidia measure 100 to 200 μ in diameter, the setae 70 to 145 by

*Formed a part of the thesis submitted and approved for the Ph.D. degree of the University of Madras.

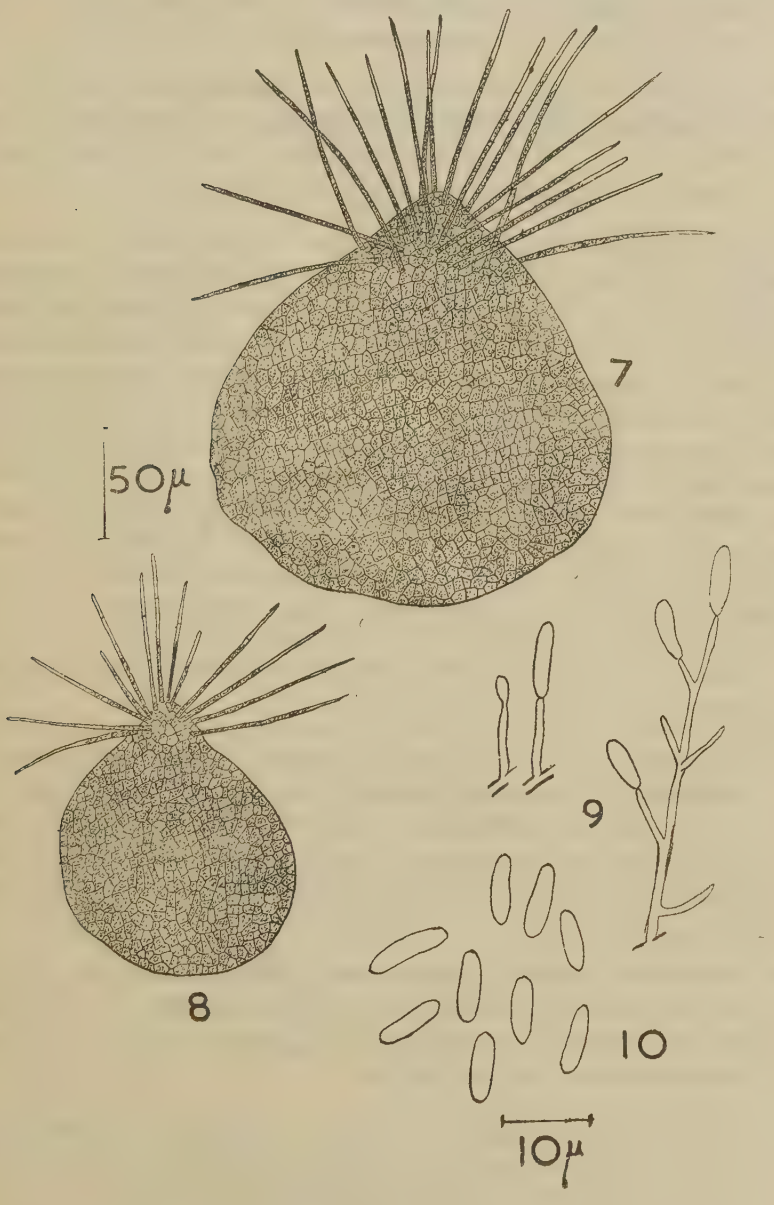
**Presently of the Department of Mycology, Tocklai Experimental Station, Indian Tea Association, Cinnamara, Assam.



FIGS. 1-6. *Phomopsis* Sp.

1. A Papillate pycnidium. 2. Pycnidum showing the ostiole. 3. & 4. Conidiophores and conidia. 5. & 6. Pycnidiospores

3 to 5μ. Spores, cylindrical with obtuse ends, 5 to 7 by 1·5 to 2·5μ, mostly 6·5 by 2μ, hyaline, without guttules. (Figs. 7-10).



Figs. 7-10. *Pyrenochaeta* sp.

7. & 8. Pycnidia showing the setae. 9. Conidiophores. 10. Pycnidiospores

38. *Aspergillus fumigatus* Fresenius in *Beiträg zur Mykologie,* 1950, p. 81; Thom, C. and Raper, K. B., *A Manual of the Aspergilli,* 1945, p. 148; Gilman, J. C., *A Manual of Soil Fungi,* 1945, p. 189; Subramanian, C. V., *J. Madras Univ.,* **22B,** 1952, p. 219; Agnihothrudu, V., *Naturwissenschaften,* **44,** 1957, p. 65.

39. *Aspergillus unguis* (Emile-Weil et Gaudin) Thom and Raper in *Mycologia,* **31,** 1939, pp. 667-668; Ramakrishnan, K. and Subramanian, C. V., *J. Madras Univ.,* **22B,** 1952, p. 7; Agnihothrudu, V., *Naturwissenschaften,* **44,** 1957, p. 65.

Colonies on Czapek solution agar slow-growing, restricted, with frayed margins, yellowish green to deep green, becoming somewhat dirty brown with age. No perithecia or hülle cells present. Interspersed with the mycelium are thick walled sterile hyphae with somewhat brownish walls, roughened surface, tapering to an obtuse point arising not infrequently from distinct foot-cells, measuring up to 800 μ in length. Conidial heads columnar up to 150 by 35 to 45 μ; conidiophores smooth walled, dull brown in colour, mostly up to 60 μ long by 3 to 5 μ in diameter. Vesicle up to 12 μ in diam., sterigmata in two series, the primaries measuring 4 to 6 μ by 2 to 3 μ the secondaries 5 to 6 by 2 to 3 μ. Conidia globose, rough, pale green, 2 to 4 μ in diam.

As far as I am aware this fungus has not been reported from Indian soils.

40. *Aspergillus ustus* (Bainier) Thom and Church in *The Aspergilli,* 1926, pp. 152-153; Thom, C. and Raper, K. B., *A Manual of the Aspergilli,* 1945, p. 141; Gilman, J. C., *A Manual of Soil Fungi,* 1945, p. 194; Subramanian, C. V., *J. Madras Univ.,* **22B,** 1952, p. 219; Agnihothrudu, V., *Naturwissenschaften,* **44,** 1957, p. 65.

41. *Aspergillus sydowi* (Bainier and Sartory) Thom and Church in *The Aspergilli,* 1926, pp. 147-148; Subramanian, C. V., *J. Madras Univ.,* **22 B,** 1952, p. 219; Agnihothrudu, V., *Naturwissenschaften,* **44,** 1957, p. 65.

42. *Aspergillus versicolor* (Vuillemin) Tiraboschi in *Ann. Bot. (Rome),* **7,** 1908, p. 7; Thom, C. and Raper, K. B., *A Manual of the Aspergilli,* 1945, pp. 190-192; Subramanian, C. V. and Ramakrishnan, K., *J. Madras Univ.,* **26 B,** 1956, p. 335; Agnihothrudu, V., *Naturwissenschaften,* **44,** 1957, p. 65.

43. *Aspergillus terreus* Thom in *Amer. J. Bot.*, **5**, 1918, pp. 85-86; Thom, C. and Raper, K. B., *A Manual of the Aspergilli*, 1945, p. 195; Gilman, J. C. *A Manual of Soil Fungi*, 1945, p. 193; Subramanian, C. V., *J. Madras Univ.*, **22 B**, 1952, p. 219; Agnihothrudu, V., *Naturwissenschaften*, **44**, 1957, p. 65.

Aspergillus terreus Thom var. *aureus* Thom and Raper in *A Manual of the Aspergilli*, 1945, p. 198; Agnihothrudu, V., *Naturwissenschaften*, **44**, 1957, p. 65.

Colonies relatively slow growing with abundant floccose aerial mycelum the colour of which changes from Marguerite Y (10 C 1) to Yellow Ochre P (11 I 7) through various shades of Reed Y (10 I 1) to Pyrite Y (12 L 3). Conidial heads produced tardily in patches of Cinnamon Br (14 I 10). In all other characters the fungus agrees with *Aspergillus terreus*.

Aspergillus terreus Thom var *floccosus* Sish in *Lignan Sci. J.*, **15**, 1936, p. 371; Thom, C. and Raper, K. B., *A Manual of The Aspergilli*, 1945, 198; Agnihothrudu, V., *Naturwissenschaften*, **44**, 1957, p. 65.

The isolate agrees with *Aspergillus terreus* in conidiophore and conidial characters. The aerial mycelium is highly floccose with very tardy production of conidial heads which are somewhat less compact than in the typical *A. terreus*.

44. *Aspergillus carneus* (van Tieghem) Blochwitz in *Ann. Mycol.*, **31**, 1933, p. 81; Thom, C. and Raper, K. B., *A Manual of the Aspergilli*, 1945, pp. 201-202; Agnihothrudu, V., *Naturwissenschaften*, **44**, 1957, p. 65.

Colonies on Czapek agar fairly rapidly growing, spreading, somewhat furrowed radially, floccose at the margins, white turning from tan to flesh colour with the aging of the culture and with the production of fruiting structures. Culture heavily sporulating throughout with the conidiophores arising from the aerial as well as the submerged mycelium. Fruiting areas appearing as bright orange to almost brown, reverse in shades of yellowish orange; conidial heads loosely columnar, measuring up to 200 by 20 to 30 μ; conidiophores of diverse lengths, but mostly measuring from 200 to 400 μ, not infrequently secondary fruiting structures are borne on short laterals on the mycelium. Diameter of the conidiophore varying from 3 to 6 μ. Vesicles somewhat hemispherical, measuring up to 10 μ in diam. Sterigmata in two distinct series, the

primaries up to 6 μ by 2 to 3 μ, the secondaries of the same length but are somewhat narrower, measuring 1·5 to 2 μ in diam. Conidia subglobose or globose, thin walled, 2-to 3 μ in diam. This fungus has not been reported from Indian soils.

45. *Aspergillus niveus* Blochwitz in *Ann. Mycol.*, **27**, 1929, pp. 205-06; Thom, C. and Raper, K. B., *A Manual of the Aspergilli*, 1945, pp. 202-204; Subramanian, C. V., and Ramakrishnan, K., *J. Madras Univ.*, **26 B**, 1956, p. 335; Agnihothrudu, V., *Naturwissenschaften*, **44**, 1957, p. 65.

46. *Aspergillus candidus* Link in *Obs.*, 1809, p. 16; Thom, C. and Raper, K. B., *A Manual of the Aspergilli*, 1945, pp. 207-210; Subramanian, C. V., *J. Madras Univ.*, **22 B**, 1952, p. 219; Subramanian, C. V. and Ramakrishnan, K., *J. Madras Univ.*, **26 B**, 1956, p. 334; Agnihothrudu, V., *Naturwissenschaften*, **44**, 1957, p. 65.

47. *Aspergillus niger* van Tieghem in *Ann. Sci. Nat. Bot. Ser.*, **5**, 1867, p. 240; Thom, C. and Raper, K. B., *A Manual of the Aspergilli*, 1945, p. 216; Subramanian, C. V., *J. Madras Univ.*, **22B**, 1952, p. 219; Agnihothrudu, V., *Naturwissenschaften*, **44**, 1957, p. 65.

48. *Aspergillus luchuensis* Inui in *J. Coll. Sci. Univ. Tokyo*, **15**, 1901, p. 469; Thom, C. and Raper, K. B., *A Manual of the Aspergilli*, 1945, pp. 229-230; Ramakrishnan, K. and Subramanian, C. V., *J. Madras Univ.*, **22 B**, 1952, p. 7; Subramanian, C.V., *J. Madras Univ.*, **22 B**, 1952, p. 219; Agnihothrudu, V., *Naturwissenschaften*, **44**, 1957, p. 65.

49. *Aspergillus japonicus* Saito in *Bot. Mag. Tokyo.*, **20**, 1906, pp. 61-63; Thom. C. and Raper, K. B., *A Manual of the Aspergilli*, 1945, pp. 230-231; Ramakrishnan, K. and Subramanian, C. V., *J. Madras Univ.*, **22 B**, 1952, p. 7; Agnihothrudu, V., *Naturwissenschaften*, **44**, 1957, p. 65.

50. *Aspergillus tamarii* Kita in *Zbl. f. Bakt.*, **37**, 1913, pp, 432-452; Thom, C. and Raper, K. B., *A Manual of the Aspergilli*, 1945, pp. 254-256; Subramanian, C. V., *J. Madras Univ.*, **22 B**, 1952, p. 219; Agnihothrudu, V., *Naturwissenschaften*, **44**, 1957, p. 65.

51. *Aspergillus flavus* Link in *Obs.*, 1809, p. 16; Thom, C. and Raper, K. B., *A Manual of the Aspergilli*, 1945, p. 263; Subramanian, C. V., *J. Madras Univ.*, **22 B**, 1952, p. 219; Agnihothrudu, V., *Naturwissenschaften*, **44**, 1957, p. 65.

52. *Aspergillus sulphureus* (Fries) Thom and Church in *The Aspergilli,* 1926, pp. 185-186; Thom, C. and Raper, K. B., *A Manual of the Aspergilli,* 1945, pp. 275-276; Subramanian, C. V., *J. Madras Univ.,* **22B,** 1952; p. 219; Agnihothrudu, V., *Naturwissenschaften,* **44,** 1957, p. 65.

53. *Aspergillus ochraceus* Wilhelm in *Inaug. Diss., Strassburg,* 1877, p. 66; Thom, C. and Raper, K. B., *A Manual of the Aspergilli,* 1945, pp. 279-281; Subramanian, C. V., *J. Madras Univ.,* **22 B,** 1952, p. 219; Agnihothrudu, V., *Naturwissenschaften,* **44,** 1957, p. 65.

54. *Aspergillus sclerotiorum* Hüber in *Phytopathology,* **23,** 1933, pp. 306-308; Thom, C. and Raper, K. B., *A Manual of the Aspergilli,* 1945, pp. 278-279; Subramanian, C. V., and Ramakrishnan, K., *J. Madras Univ.,* **26 B,** 1956, p. 335; Agnihothrudu, V., *Naturwissenschaften,* **44,** 1957, p. 65.

55. *Aspergillus melleus* Yukawa in *J. Coll. Agric. Tokyo,* **1,** 1911, p. 366; Thom, C. and Raper, K. B., *A Manual of the Aspergilli,* 1945, p. 279; Agnihothrudu, V., *Naturwissenschaften,* **44,** 1957, p. 65.

Colonies on Czapek Dox agar spreading rapidly, with abundant aerial mycelium in which are intermingled the conidiophores. The fungus produces, very often whitish-yellow or honey-brown coloured sclerotia. Reverse of the culture in shades of reddish-brown. Conidial heads produced abundantly, spherical to begin with, splitting at length into long columnar masses measuring up to 400 μ in diameter. Conidiophore walls yellowish, the pitted nature of which could be made out in dry mounts, measuring up to 800 μ long by 50 to 20 μ in diam. Vesicles up to 50 μ in diam., globose to pyriform; sterigmata biseriate, primaries measuring up to 20 μ by 2 to 4 μ; secondaries up to 8 μ by 2 to 3 μ. Conidia are borne in long chains, thin walled, smooth, somewhat elliptic, measuring about 3 μ in long axis. Sclerotia ranging in size from 350 to 600 μ. The fungus has not been reported from Indian soils before.

56. *Sporotrichum pruinosum* Gilman and Abbott in *Iowa State Coll. J. Sci.,* **1,** 1927, p. 283; Gilman, J. C., *A Manual of Soil Fungi,* 1945, p. 266.

Colonies fast growing on Czapek Dox agar, pure white, spreading with a mealy or dusty appearance with the production of the

conidiospores. Mycelium hyaline, branched, septate, varying in diameter from 3 to 8 μ. Fertile branches erect, arising as laterals, opposite or alternately disposed or irregular in arrangement, highly ramified. Conidiophores varying in length from 15 to 35 μ. Conidia are borne on short unbranched laterals on the mycelium, subelliptic, hyaline, smooth walled, measuring 8 to 15 by 4 to 9 μ in diam. The detached conidia show distinct, short, attachment papilla at the base.

57. *Trichoderma viride* Pers. *ex* Fr. Saccardo in *Syll. Fung.*, **4**, 1886, p. 59; Gilman, J. C. *A Manual of Soil Fungi*, 1945, p. 183; Subramanian, C.V., *J. Madras Univ.*, **22 B**, 1952, p. 221.

58. *Gliocladium fimbriatum* Gilman and Abbot *Iowa State Coll. J. Sci.*, **1**, 1927, p. 307; Gilman, J. C., *A Manual of Soil Fungi*, 1945, p. 263; Raper, K.B., and Thom, C., *Manual of the Penicillia*, 1949, pp. 684-685.

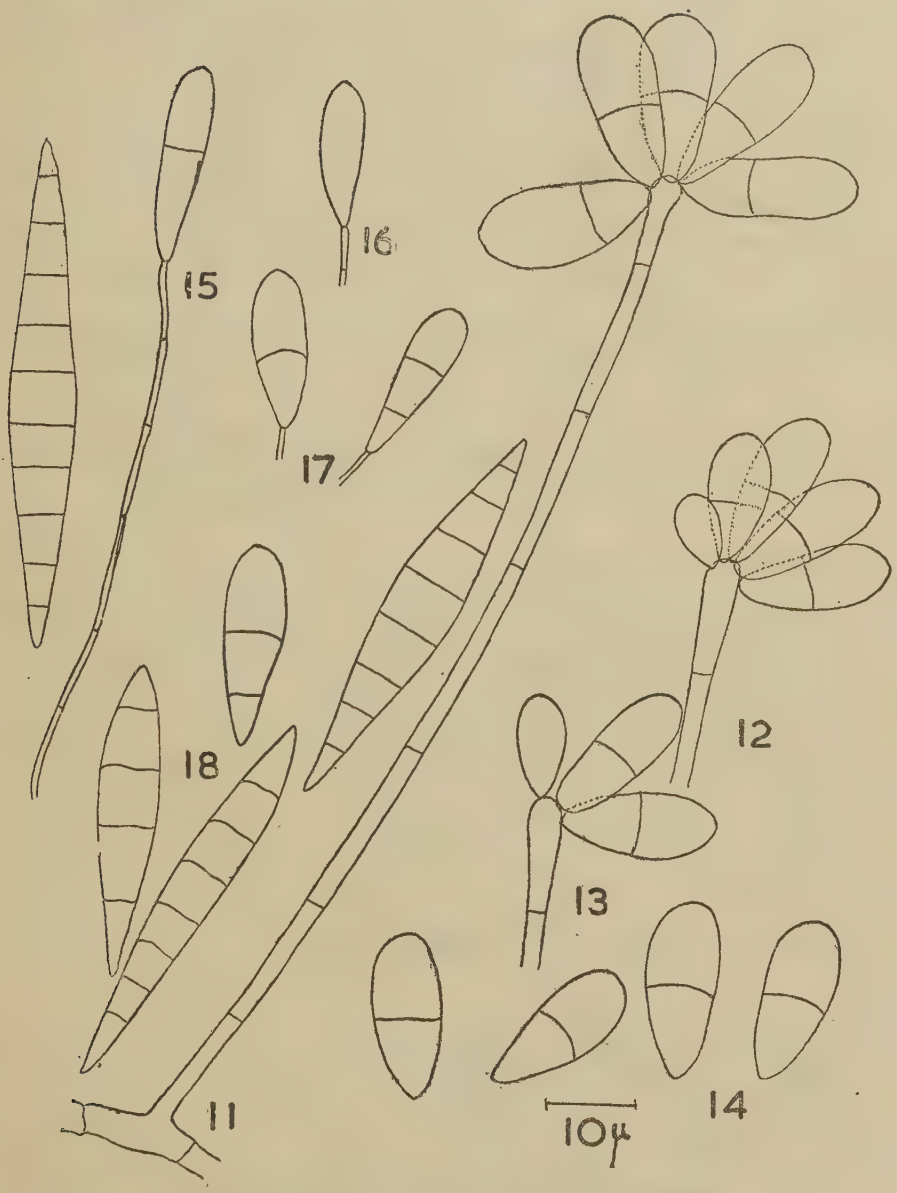
Colonies broadly spreading with zones of dark leaf green fruiting areas appearing near the centre of the colony and spreading centrifugally. Conidiophores arising from the aerial mycelium, smooth, up to 30 μ long. Spore heads are enveloped in balls of slime in which the chains of conidia are indistinguishable. Fructifications are composed of fertile branches in two stages with divergent branches or metulae which bear flask-shaped phialides on which the conidia are produced acropetally and get entangled in a mass of mucilaginous matrix to form spore-balls. In some heads one or more branches arise laterally from the conidiophores some distance below the main head 9 to 16 by 2 to 4 μ, phialides up to 14 μ long. Conidia elliptic or ovoid, smooth, pale green 5·2 to 8·8 by 2·4 to 4 μ.

59. *Trichothecium roseum* Link in *Spec. Plant.* **1**, 1824, p. 28; Saccardo, *Syll. Fung.*, **4**, 1886, p. 180; Gilman, J. C., *A Manual of Soil Fungi*, 1945, p. 280; Mundkur, B.B., *Sci. Monogr. Coun. agric. Res. India*, **12**, 1938, p. 37.

This fungus has not been previously reported from Indian soils (Figs. 11-14).

60. *Arthrobotrys superba* (Corda) Saccardo in *Syll. Fung.*, **4**, 1886 Drechsler, C., *Mycologia*, **29**, 1934, pp. 450-459; Mundkur, B. B., *Sci. Monogr. Coun. agric. Res. India*, **12**, 1938, p. 31.

Colonies snow-white or somewhat buff coloured, effuse, presenting a powdery appearance due to the presence of conidial

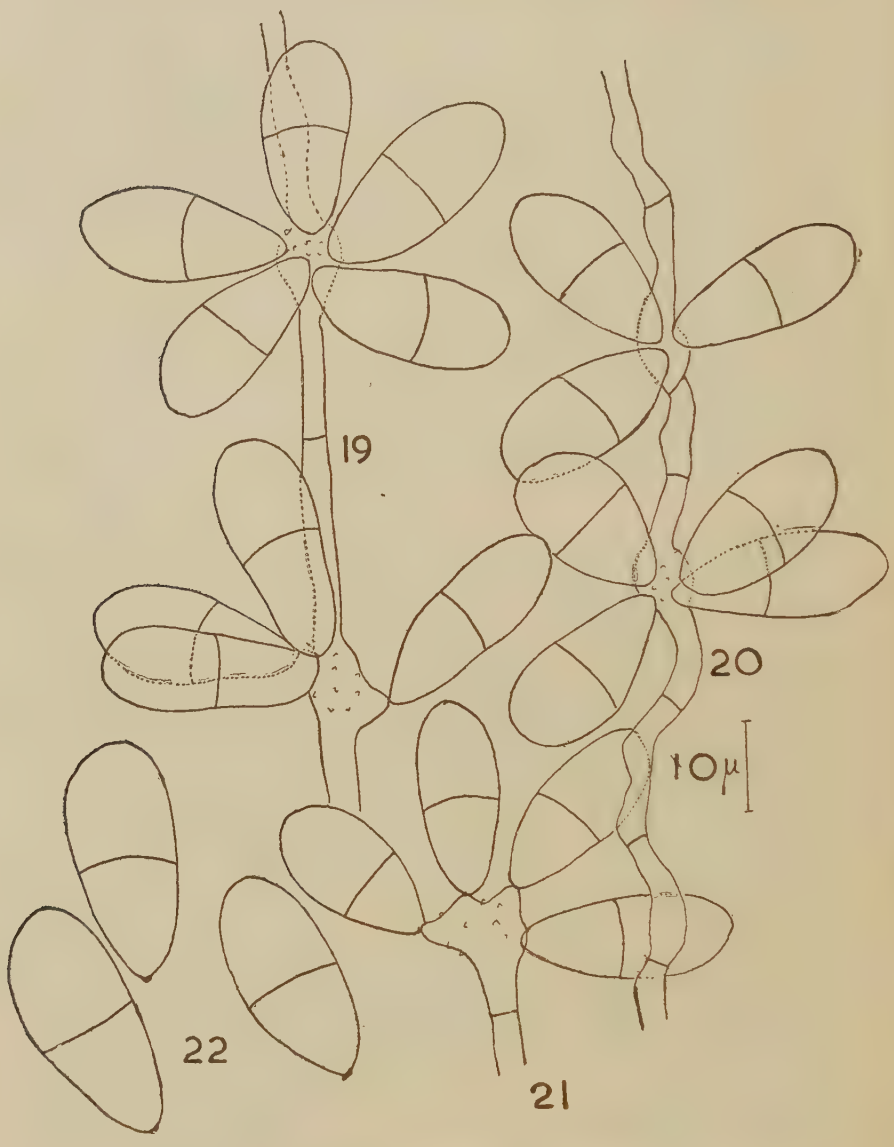


Figs. 11-14. *Trichothecium roseum* Link

11. Conidiophore and conidia. 12. & 13. Apex of the conidiophore bearing the conidia. 14. Conidia

Figs. 15-18. *Dactylella* sp.

15. Conidiophore and Conidium. 16-18. Conidia in different stages of development



FIGS. 19-22. *Arthrobotrys superba* (Corda) Sacc.

19-20. Conidiophore showing intercalary swelling bearing the Conidia.

21. A terminal swelling with denticulations bearing the Conidia.

22. Conidia

aggregates. Sterile hyphae decumbent, septate, branched, 3 to 5 μ; fertile branches erect, simple, septate, 250 to 700 μ long by 3 to 5 μ with terminal and intercalary swellings provided with minute denticulations on which the conidia are borne. Conidia obovate, 1-septate, divided into unequal halves, hyaline, usually with the hilum present on the inferior cell, measuring 16 to 27 by 10 to 14 μ, average 23 by 13 μ mostly 24 by 13 μ. It is very likely that this fungus is present as a predator on the nematodes occuring in the rhizosphere (Figs. 19-22).

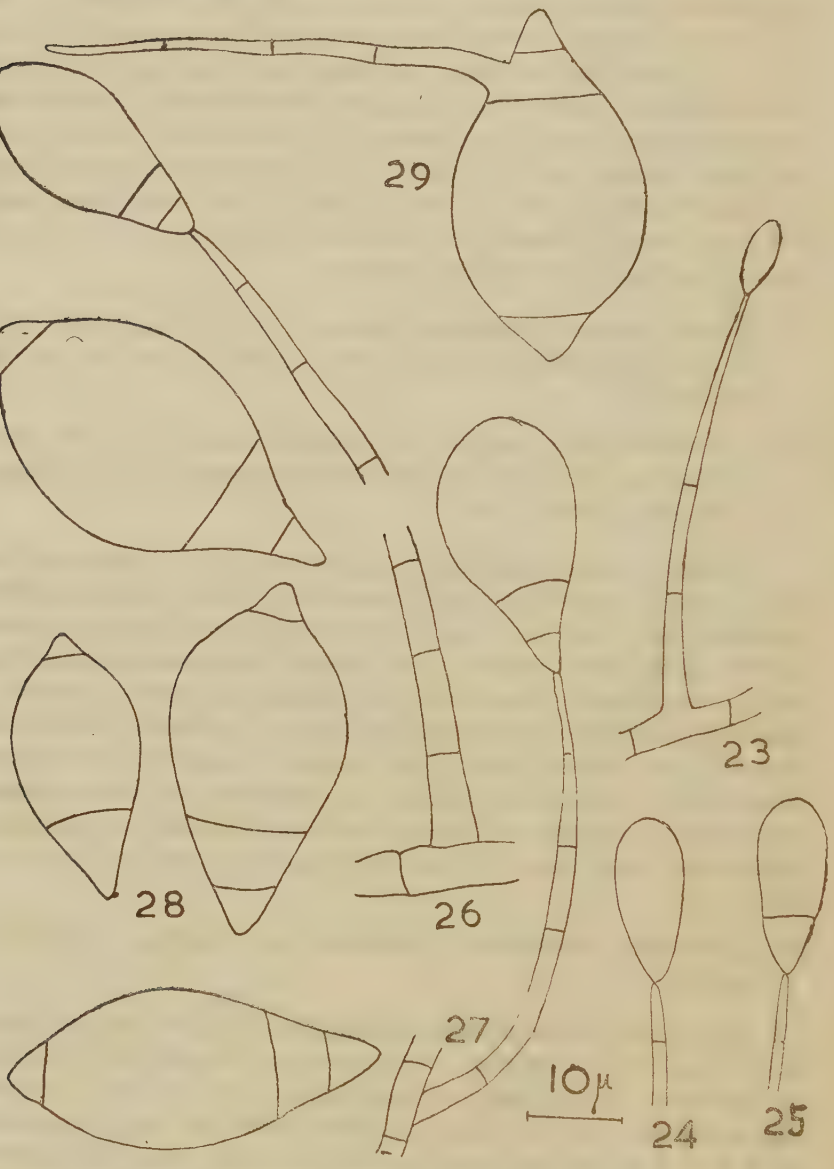
61. *Cephaliophora irregularis* Thaxter in *Bot. Gaz.*, **35**, 1903, p. 158; Subramanian, C. V., *Proc. Indian Acad. Sci.*, **37 B**, pp. 96-98.

62. *Cylindrocladium scoparium* Morgan in *Bot. Gaz.*, **17**, 1892, p. 190; Ramakrishnan, K. and Subramanian, C. V., *J. Madras Univ.*, **22 B**, 1952, p. 16.

Colonies white, powdery in appearance on the surface of the root. Sterile mycelium highly ramified, hyaline, septate. Main branches bear 1 or more monopodially branched fertile secondary laterals at different heights. The primary branches end in a long, sterile spear-head. Sometimes the spear-like sterile branch is absent and only the penicillate fertile head is produced bearing the conidia. The fertile laterals are cymosely branched 1 to 3 times. The ultimate branches of the laterals (phialides) get closely aggregated and measures 6 to 10 by 3 to 4 μ. Conidia are bicellular, cylindrical with obtuse apices, measuring 32 to 50 by 3 to 4 μ in diam.

63. *Dactylella bembicodes* Drechsler in *Mycologia*, **29**, 1937, p. 491.

Mycelium somewhat effuse, vegetative hyphae septate, mostly 2 to 4·8 μ wide, branched. No ensnarement rings were observed in cultures. Conidiophores erect, septate, 250 to 500 μ, mostly 300 to 400 by 5 to 7 μ; wider at the base gradually tapering apically to 2 to 3 μ at the tip bearing usually a single conidium acrogenously. Conidia hyaline, turbinate, broadly rounded apically, tapering towards the slightly protruding truncate base, 30 to 40 by 16 to 22 μ, mostly 40 by 20 μ; regularly divided by 3 septa into four cells, obconical, the antipenultimate cell disciform, the penultimate cell ventricose or inflated doliform and the apical cell conoid-hemispheric. (Figs. 23-29).



FIGS. 23-29. *Dactylella bembicodes* Drechsler

23-27. Conidiophores and Conidia in different stages of development.

28. Mature Conidia. 29. A germinating Conidium

This species like *Arthrobotrys superba* (Corda) Sacc. is in all probability associated with the nematodes in the rhizosphere.

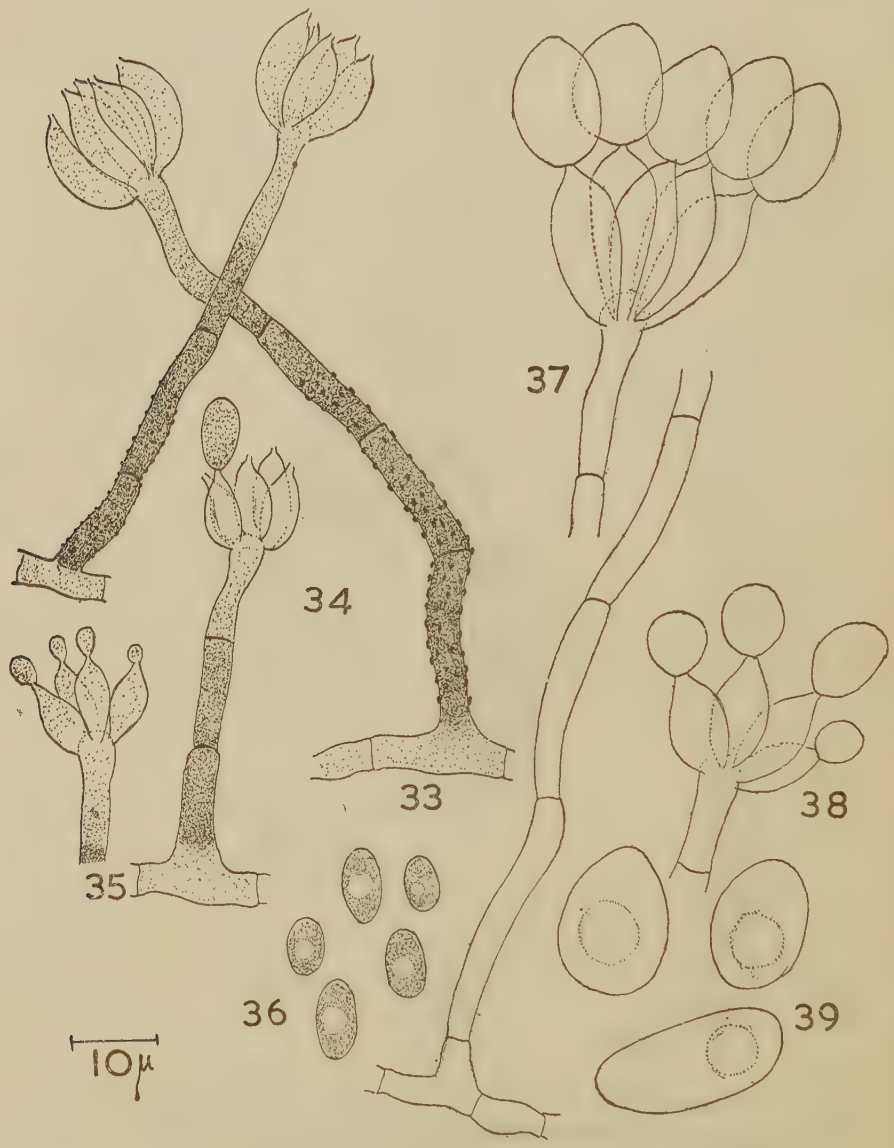
64. *Dactylella* sp.

Figs. 30-32. *Pullularia pullulans* (de Bary) Berhout

30. Young mycelial cells showing budding of the radulaspores. 31. Coloured thick walled mycelial cells. 32. Spores

Colonies white, effuse, sterile mycelium sparse, repent, fertile hyphae erect, conidiophores slender, sparsely septate, hyaline, un-

branched. Conidia borne singly, acrogenously, 3 to 7-septate, hyaline, pyriform when young, becoming fusiform with maturity. Apices of the conidia acute, 28 to 50 μ by 5 to 8 μ; average 38·5 by 6·5 μ, mostly 36 by 7 μ. (Figs. 15-18).



Figs. 33-36. *Stachybotrys atra* Corda
33-35. Conidiophores and phialides. 36. Spores
Figs. 37-39. "Pink *Stachybotrys*"
37-38. Phialides bearing conidia. 39. Conidia

65. *Torula herbarum* (Pers.) Link *ex* Fr. in *Syst. Mycol.*, **3**, 1832, p. 501; Saccardo, *Syll. Fung.*, **4**, 1886, p. 256; Subramanian C. V., *Proc. Indian Acad. Sci.*, **36 B**, 1952, pp. 43-45.

*66. *Stachybotrys atra* Corda *Icones Fungorum*, **1**, 1837, p. 21; Saccardo, *Syll. Fung.*, **4**, 1886, p. 69; Bisby, G. R., *Trans. Brit. mycol. Soc.*, **26**, 1943, pp. 133-143; Subramanian, C. V., *Proc. Indian Acad. Sci.*, **36 B**, 1952, p. 48-50.

A strain of 'pink *Stachybotrys*' was isolated from the root surface of pigeon-pea plants. Colonies fast growing, on Czapek Dox ager with yeast extract, white at first, turning pale pink with the production of conidia. Conidiophores simple, arising from the substrate mycelium 80 to 144 by 4 to 7 μ; smooth walled, hyaline, phialides varying in number from 4 to 8 mostly 5·8 to 14 by 6 to 10 μ, mean 12·3 by 7·3 μ, mostly 12·8 by 8 μ. Conidia ovate to cylindrical, pale pink, smooth walled with one or two oil globules, 11 to 18 by 8 to 11 μ, mean 12·5 by 9·3 μ mostly 12·8 by 9·6 μ, (Figs. 37-39).

This isolate is in all probability a species of the newly erected genus *Hyalostachybotrys* K. V. Srinivasan (*J. Indian Bot. Soc.*, **37**, 1958, pp. 334-342).

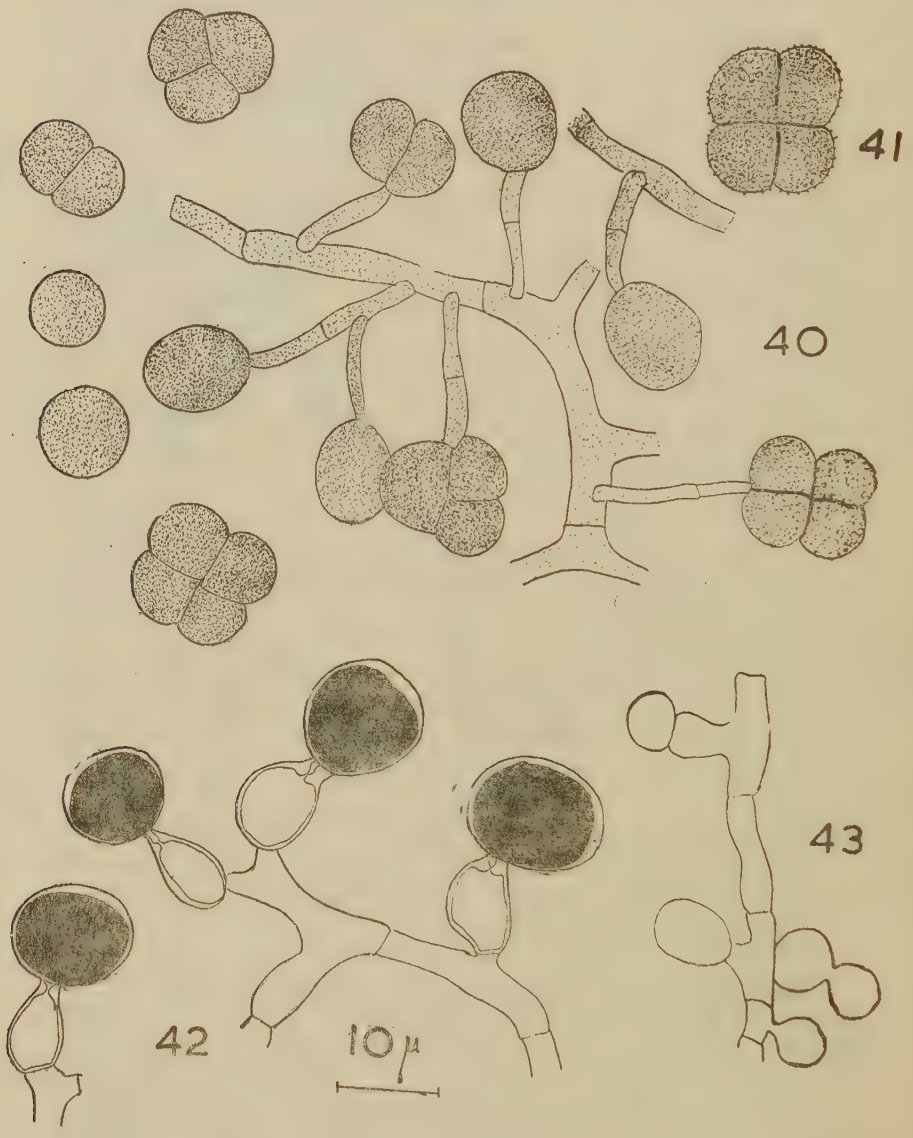
67. *Memnoniella echinata* (Riv.) Galloway in *Trans. Brit. mycol. Soc.*, **18**, 1933, pp. 163-166; Bisby, G. R., *Trans. Brit. mycol. Soc.*, **26**, 1943, pp. 133-143; Subramanian, C. V., *Proc. Indian Acad. Sci.*, **36 B**, 1952, p. 50.

68. *Nigrospora oryzae* (Berk. and Br.) Petch in *Trans. Brit. mycol. Soc.*, **12**, 1927, pp. 152-165; Saccardo, *Syll. Fung.*, **25**, 1931, p. 775; Subramanian, C. V., and Ramakrishnan, K., *J. Madras Univ.*, **26 B**, 1956, p. 358.

Sterile mycelium creeping at first, hyaline, becoming dark in colour with age of the culture, septate, up to 10 μ in diam., fertile hyphae 3·2 to 6·4 μ in diam., subhyaline to pale brown or fuscous in colour bearing terminally and laterally typical basisporium apparatus consisting of a short hyaline or subhyaline flask-shaped conidiophores (flask cells) on which the black, opaque spores are produced singly. Spores globose, smooth walled, 10 to 16 μ mostly

**Stachybotrys Chartarum* (Ebrenb.) Hughes Comb. Nov.

14 μ. The spores are surrounded by a thin evanescent mucous layer which is absent in older spores. (Figs. 42 and 43).



Figs. 40-41. *Stemphylium paxianum* (von Szabo) Lindau

40. Conidiophores. 41. The cruciate spores

Figs. 42-43. *Nigrospora oryzae* (Berk. et Br.). Petch.

42. The basisporium apparatus and the spores. 43. Young developing conidia

69. *Hormodendrum resinae* Lindau, Gilman, J.C., *A Manual of Soil Fungi,* 1945, p. 296.

Turf effuse, usually collapsing with age, brownish green, floccose, sterile hyphae septate, subhyaline, branched, 2 to 3·5 μ in diam. Fertile hyphae brown, erect septate, 5 to 6 μ, broader at the base narrowing apically, up to 3 μ at the tip. Branching of the fertile hyphae is confined to the tips only; branches are disposed alternately; branchlets hyaline, forming short chains of conidia which are hyaline when young becoming olivaceous brown in colour, elliptic, with obtuse apices, 4·8 to 7 by 4 to 5 μ, mostly 6 by 5 μ.

70. *Cladosporium herbarum* (Pers.) Link. Saccardo, *Syll. Fung.,* **4,** 1886, p. 363; Butler, E. J. and Bisby, G. R., *Sci. Monogr. Coun. agric. Res. India,* **1,** 1931, p. 145.

71. *Pullularia pullulans* (de Bary) Berkhout, Gilman, J. C., *A Manual of soil Fungi,* 1945, p. 286; Subramanian, C. V., and Ramakrishnan, K., *J. Madras Univ.,* **26 B,** 1956, pp. 368-369.

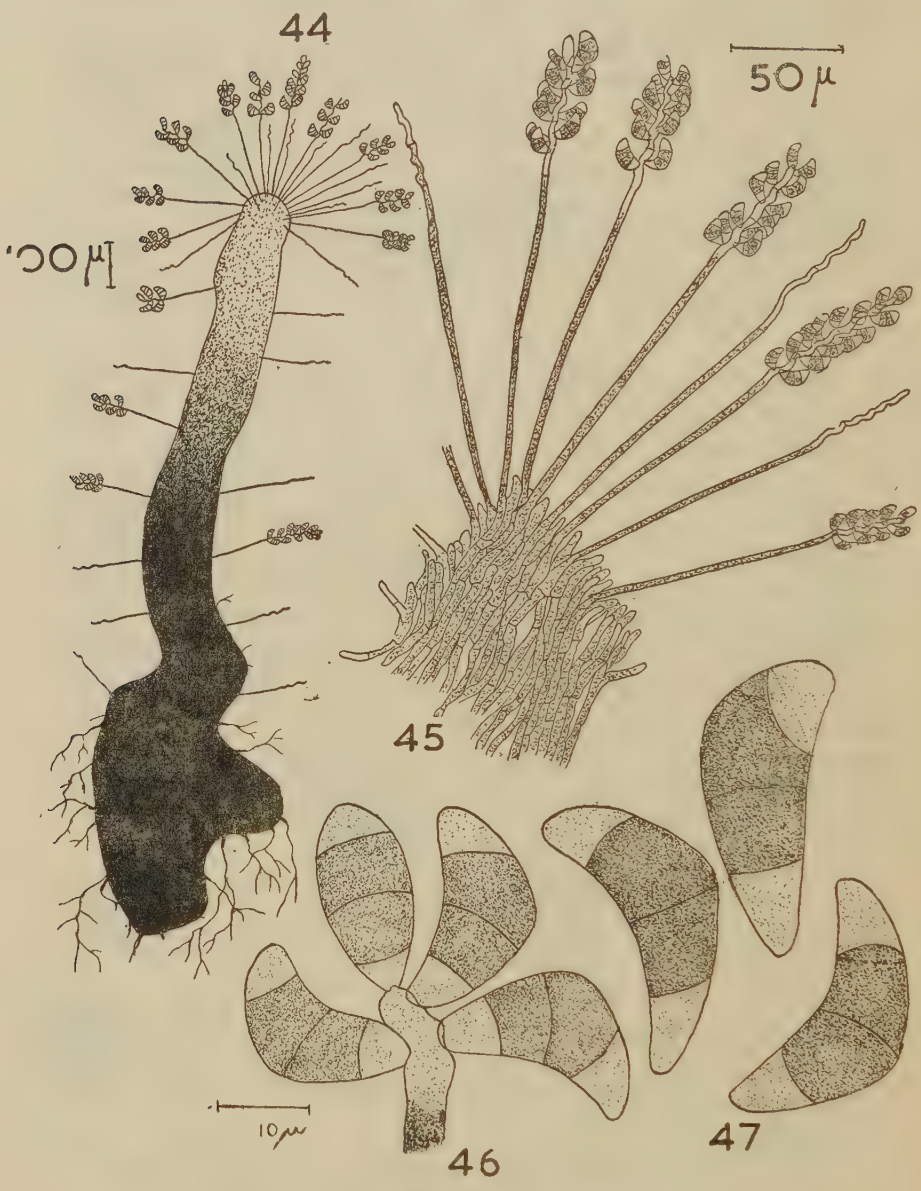
Colonies slow growing, restricted on Czapek agar with slimy, moist appearance, white at first, becoming brown and then almost black with age. Hyphae composed of chains of dark, thick walled cells connected by strands of thin-walled cells. Conidia (blastophores) or slimy radulaspores or sprout cells produced all over the mycelium pleurogenously, multiplying by gemmation. Mycelial cells become dark brown with thick walls with the aging of the culture. The fungus has apparently not been reported from Indian soils. (Figs. 30-32).

72. *Curvularia pallescens* Boedijn in *Bull. Jard. Bot., Buitenzorg,* Ser III, **13,** 1933, p. 127; Subramanian, C. V., *Proc. Indian Acad. Sci.,* **38 B,** 1953, pp. 29-30; Subramanian, C. V., and Ramakrishnan, K., *J. Madras Univ.,* **26 B,** 1956, p. 345.

73. *Curvularia lunata* (Wakker) Boedijn in *Bull. Jard. Bot., Buitenzorg,* Ser. III, **13,** 1934, p. 127; Gilman, J. C., *A Manual of Soil Fungi,* 1945, p. 304; Subramanian, C. V., *Proc. Indian Acd. Sci.,* **38 B,** 1953, p. 28-29.

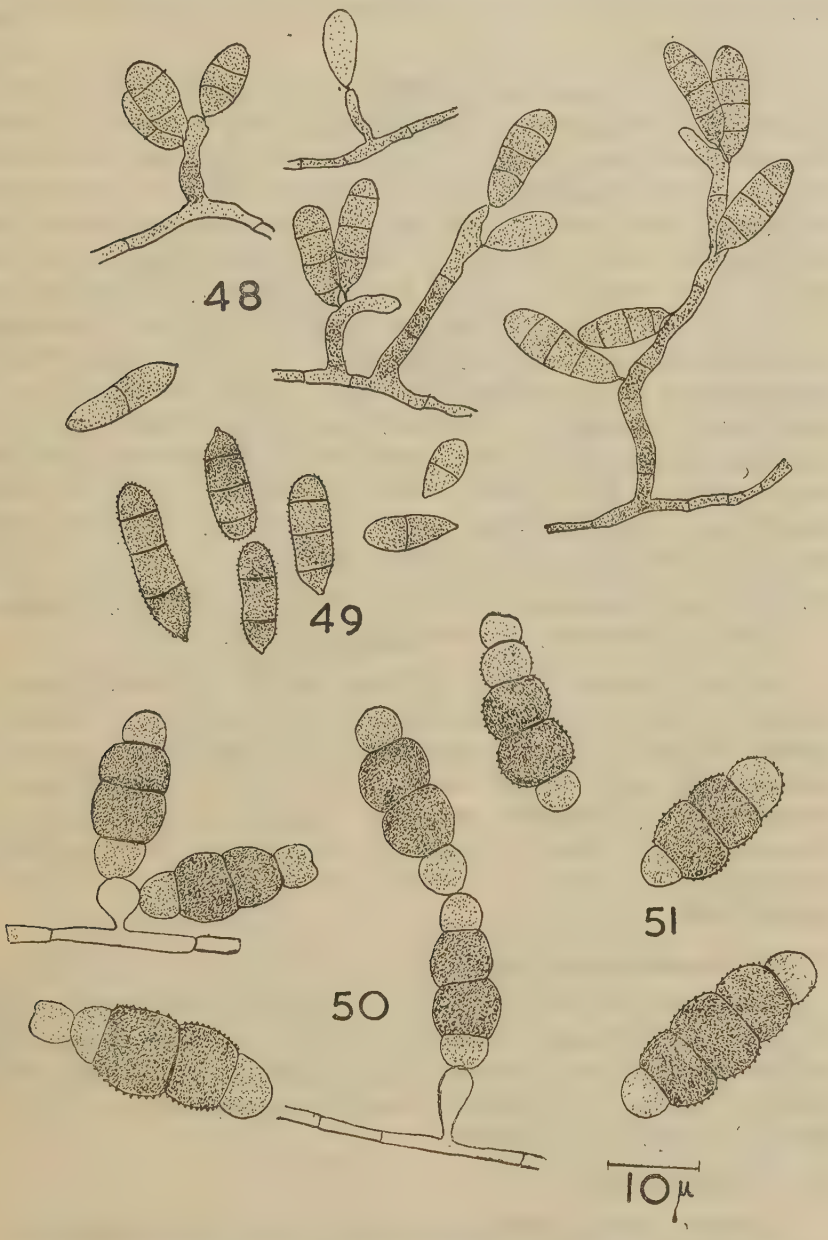
In one of the isolates long columnar stromata bearing conidiophores and conidia were observed. (Figs. 44-47).

74. *Curvularia maculans* (Bancroft) Boedijn in *Bull. Jard. Bot., Buitenzorg,* Ser. III, **13,** 1933, p. 125; Subramanian, C. V., *Proc. Indian Acad. Sci.,* **38 B,** 1953, p. 27; Subramanian, C. V. and Ramakrishnan, K., *J. Madras Univ.,* **26 B,** 1956, p. 345.



FIGS. 44-47. *Curvularia lunata* (Wakker) Boedijn

44. Stroma bearing conidia and conidiophores. 45. The apical part of the stroma. 46. The terminal part of the conidiophore showing geniculations and the conidia. 47. Conidia



FIGS. 48-49. *Heterosporium terrestre* Atkinson
48. Conidiophores and Conidia. 49. Conidia.

FIGS. 50-51. *Septonem* sp.
50. Conidia and conidiophores. 51. Conidia

75. *Heterosporium terrestre* Atkinson in *Mycologia,* 44, 1953, p. 813-822.

Colonies brownish-black, velvetty, gradually becoming covered with olive buff aerial mycelium, slow-growing restricted; hyphae septate, terete, pale olive in colour, 1·5 to 3 μ wide, profusely branched. Conidiophores hyaline to subhyaline or pale olive brown in colour, lateral, short cylindrical or slightly clavate, straight or slightly bent, with occasionally a knob-like projection, varying in length from 4·5 to 9 by 2 to 3 μ, mean 8·2 by 2·1 μ, continuous or 1 to 2-septate. Spores borne acrogenously first, later becoming pleurogenous, single or in groups of 2 or more on sterigmatoid projections of the conidiophore which are usually indistinct. Conidia ovoid to elongate, cylindrical, hyaline to subhyaline when young becoming dilute olive brown with age, smooth, later on verrucose with 2 to 3 septa, slightly constricted in the middle, basally apiculate, measuring 5 to 11 by 3 to 5 μ (including the 0-, 1- and 2-septate spores). (Figs. 48-49).

*76. *Helminthosporium anomalum* Gilman and Abbott, Gilman, J. C., *A Manual of Soil Fungi,* 1945, p. 365.

Colonies floccose with abundant aerial mycelium, sterile mycelium brown, septate, branched, 5 to 6 μ in diam. Conidiophores arising from the submerged mycelium, simple, smooth, septate with conidia borne terminally and laterally on short geniculations. Conidiophores varying in length from 115 to 450 μ. Conidia elongate, straight, obtuse at either end, 5- to 10- septate, mostly 6- or 7- septate, 30 to 90 by 11 to 16 μ mean 76·8 by 13·6 μ. (Figs. 52-56).

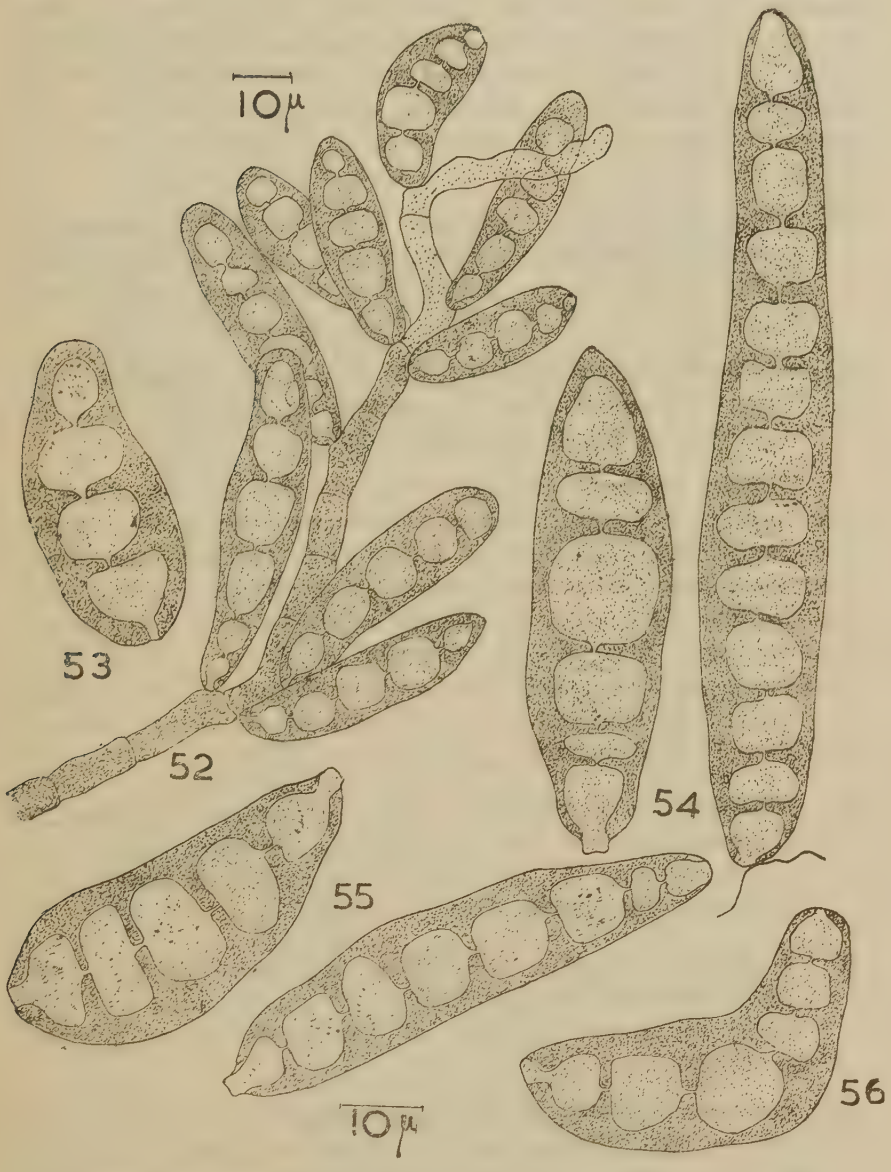
77. *Helminthosporium* sp.

Conidiophores dark brown, erect, somewhat geniculate at the tip; up to 6 μ in diam., measuring 28 to 60 μ in length, subhyaline at the apex. Conidia borne in spiral fashion, cylindrical with rounded apices, 3 to 5-septate, mostly 5-septate, measuring 16 to 24 by 6 to 8 μ. (Figs. 57-60).

78. *Septonema* sp.

Colonies slow growing on Czapek agar, greyish-brown in colour. Hyphae branched, septate, pale brown, smooth, verrucose.

*_Helmisporium_ Link according to Hughes, S.J., Canad. J. Bot., 36, 1958, p. 775.



FIGS. 52-56. *Helminthosporium anomalum* Gilman and Abbott
52. Conidiophores and conidia. 53-56. Conidia of different shapes and sizes

Conidiophores as short, rounded, lateral outgrowths of the hyphae. Conidia catenulate, chains single or in groups of three on the conidiophores. Conidia broadly fusiform in outline, broader in the middle and narrower at the ends, usually 4-septate, strongly constricted at the septa, subhyaline when young, later becoming verrucose with age, 19 to 29 by 6 to 10 μ, mean 27·2 by 8·1 μ. (Figs. 50 and 51).

79. *Alternaria humicola* Oudemans in *Archiv. Neerlanderises des Exactes et Nat.*, 1902, p. 272; Saccardo, *Syll. Fung.*, **18**, 1906, p. 624; Gilman, J. C., *A Manual of Soil Fungi*, 1945, p. 310; Subramanian, C. V., *J. Madras Univ.*, **22 B**, 1952, p. 219.

80. *Stemphylium paxianum* (von Szabó) Lindau; Wiltshire, S. P., *Trans. Brit mycol. Soc.*, **21**, 1938, pp. 211-239; Gilman, J. C., *A Manual of Soil Fungi*, 1945, p. 307.

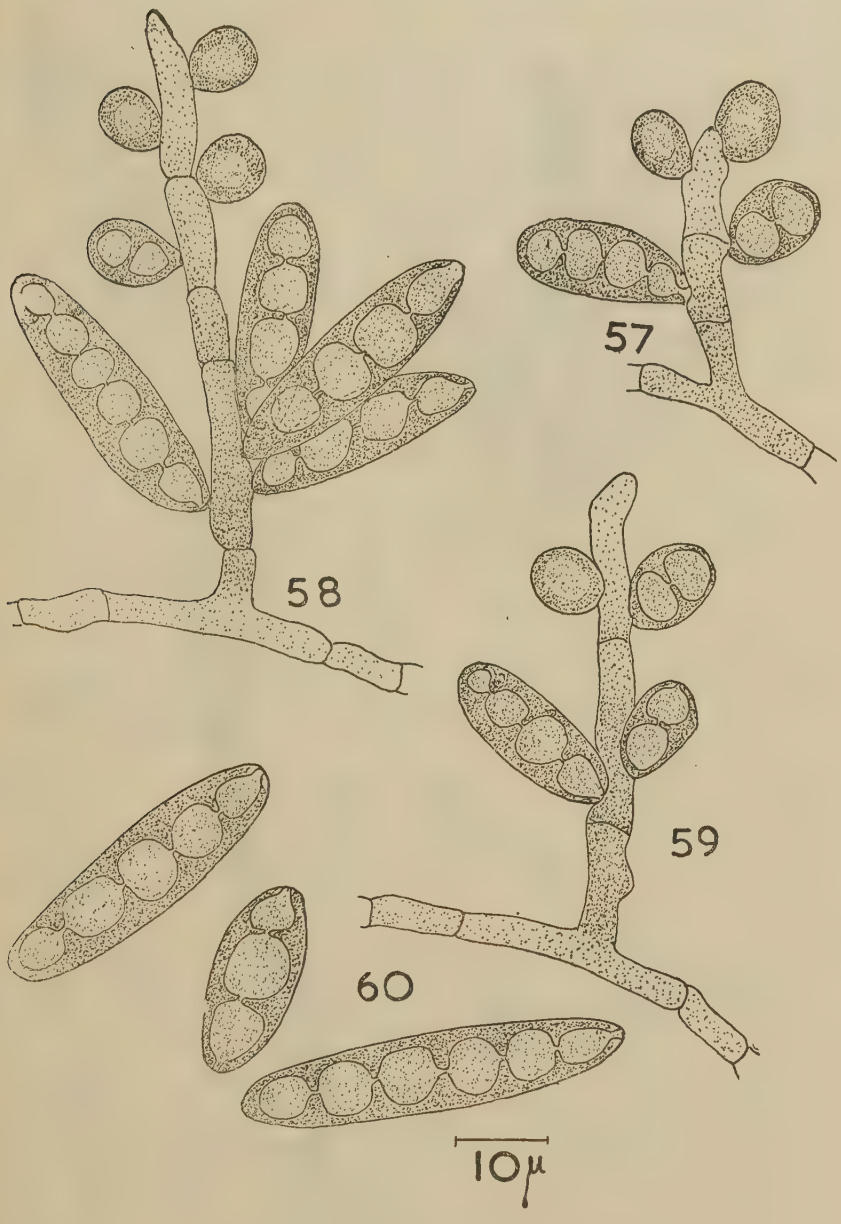
Colonies moderately fast growing on potato dextrose agar with grey aerial mycelium. Colour on the reverse deep brown. Mycelium branched, septate, hyaline, 2·5 to 4 μ. Conidiophores arising from the submerged or aerial mycelium, simple or once branched, multiseptate, olive in colour, smooth, up to 50 μ by 4- to 5 μ broad. Conidia borne terminally and laterally, singly or in heads 3- to 4-celled, cruciately septate, hyaline to subhyaline when young, becoming dark brown with age and markedly verrucose, measuring 10 to 18 μ in diameter. (Figs. 40 and 41).

81. *Fusarium chlamydosporum* Wollenweber and Reinking in *Phytopathology*, **15**, 1925, p. 156; *Die Fusarien*, 1935, p. 47; Subramanian, C. V., *Proc. nat. Inst. Sci. India*, **18**, 1952, p. 561; *J. Madras Univ.*, **24 B**, 1954, pp. 23-24.

82. *Fusarium semitectum* Berk. et Rav. in *Grevillea*, **3**, 1875, p. 98; Wollenweber, H. W. and Reinking, O. A., *Die Fusarien*, 1935, p. 58; Subramanian, C. V., *J. Madras Univ.*, **24 B**, 1954, pp. 25-26.

83. *Fusarium equiseti* (Corda) Sacc; Saccardo in *Syll. Fung.*, **4**, 1886, p. 707; Wollenweber, H. W. and Reinking, O. A., *Die Fusarien*, 1935, p. 63; Bugnicourt, F., *Encyclopedie mycol.*, **11**, 1939, p. 60; Subramanian, C. V., *Proc. nat. Inst. Sci. India*, **18**, 1952, p. 564; *J. Madras Univ.*, **24 B**, 1954, pp. 28-29.

84. *Fusarium scirpi* Lamb. et Fautr.; Wollenweber, H. W. and Reinking, O. A., *Die Fusarien*, 1935, p. 66; Subramanian, C. V.,



FIGS. 57-60. *Helminthosporium* sp.

57-59. Conidiophores bearing conidia in different stages of development. 60. Conidia

FIGS. 61-65. *Stysanus stemonites* (Pers.) Corda

61. An aggregate of coremia. 62. An enlarged coremium. 63-64. Flask-shaped phialides bearing the conidial chains. 65. Spores

Proc. nat. Inst. Sci. India, **18,** 1952, p. 566; *J. Madras Univ.,* **24 B,** 1954, pp. 30-32.

85. *Fusarium culmorum* (W. G. Smith) Saccardo in *Syll. Fung.,* **11,** 1895, p. 651; Wollenweber, H. W., and Reinking, O. A., *Die Fusarien,* 1935, p. 79; Subramanian, C. V., *Proc. nat. Inst. Sci. India,* 18, 1952, p. 570; *J. Madras Univ.,* **24 B,** 1954, p. 33.

86. *Fusarium vasinfectum* Atk., in *Alabama agric. Exp. Sta. Bull.,* **41,** 1892, p. 19; Wollenweber, H. W. and Reinking, O. A., *Die Fusarien,* 1935, pp. 124-126; Bugnicourt, F., *Encyclopedie mycol.,* **11,** 1939, p. 11; Subramanian, C. V., *Proc. nat. Inst. Sci. India,* 18, 1952, pp. 273-285; *J. Maaras Univ.,* **24 B,** 1954, p. 37.

87. *Fusarium udum* Butler in *Mem. Dept. Agric. India,* **2,** 1910, p. 54; Wollenweber, H. W., *Arb. biol. Reichsant. Land- u. Forst.,* **22,** 1938, p. 339-347; Padwick, G. W., *Indian J. agric. Sci.,* **11,** 1941, p. 672; Subramanian, C. V., *J. Madras Univ.,* **24 B,** 1954, pp. 37-38.

88. *Fusarium solani* (Mart.) Appel and Wollenweber; Wollenweber, H. W., and Reinking, O. A., *Die Fusarien,* 1935, p. 135; Bugnicourt, F., *Encyclopedie mycol.,* **11,** 1939, p. 141; Subramanian, C. V., *Proc. nat. Inst. Sci. India,* **18,** 1952, p. 577.

89. *Stysanus stemonites* (Pers.) Corda in *Icones Fungorum,* **1,** 1837, p. 22; Saccardo, *Syll. Fung.,* **4,** 1886, Gilman, J. C., *A Manual of Soil Fungi,* 1945, p. 314; Subramanian, C. V., *J. Madras Univ.,* **22 B,** 1952, p. 221.

Colonies fast growing on potato dextrose agar and Czapek-Dox agar amended with yeast extract, compact, greyish first, turning olive green. On Tornton agar the colonies are slow growing with sparse aerial mycelium and coremia are produced not so abundantly as in Czapek-Dox agar. Coremia gregarious, erect, cylindro-clavate, simple, dark brownish in colour, varying in length from 200 μ to 1 mm; fertile in the upper two-thirds of the coremium. Stipe formed of hyphae running parallel upwards towards the apex and slightly diverging on the sides bearing flask-shaped sterigmata, 5·6 by 2·5 to 3·2 μ. Conidia borne in long chains, smooth walled, oval or lemon-shaped, pale greenish or pale brownish, subhyaline to transluscent in colour, 6·4 to 8 by 4 to 5 μ, mostly 8 by 4·8 μ. (Figs. 61-65).

FIGS. 66-69. *Trichurus* sp.

66. Coremia. 67. Enlarged apex of the coremium showing phialides, conidia and sterile hairs. 68. Phialides and conidial chains. 69. Conidia

90. *Trichurus* sp.

Coremia gregarious, olivaceous black in colour. In culture, colonies grow with irregular frayed margins, pale olive green in colour, becoming greyish with aging of the culture. With the production of conidial chains, the coremia present a powdery or dusty appearance. Total height of the coremia up to 2 mm. Stipe composed of parellel hyphae, measuring 400 to 800 by 30 to 40 μ. Fertile part up to 1 mm long giving rise to long chains of elliptic or oval conidia. Conidia 3 to 4 by 2 to 3 μ, borne on flask-shaped phialides, 4 to 8 by 2 to 3 μ in diam. The fertile part of the coremia is interspersed with long unbranched, brownish bristles measuring 400 μ long, straight or slightly flexuous. (Figs. 66-69).

Acknowledgments

The author is grateful to Prof. Dr. T. S. Sadasivan and Dr. C. V. Subramanian for their valuable suggestions and criticism and to the University of Madras for the award of a research studentship during the tenure of which this work was done.

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Studies on the Progeny of Quadruple Monosomic *Pennisetum Purpureum* Schum.

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ABSTRACT

A 45 and a 38-chromosomed plant were raised from an open-pollinated quadruple monosomic *Pennisetum purpureum* Schum. (2n=24). Based on the meiotic associations of these two plants, their genomic constitutions, as well as their mother plant's, have been analysed. It is concluded that, by natural cross pollination, an amphidiploid *Pennisetum* and diploid *P. purpureum* might have been the male parents for the origin of the 45 and 38-chromosomed progenies respectively.

On pollination with *P. typhoides* Stapf. & Hubb., the quadruple monosomic *P. purpureum* (2n=24) produced a 24-chromosomed plant which is suggested to have arisen through parthenogeny of an unreduced egg.

Introduction

The Napier grass, *Pennisetum purpureum* Schum., is considered to be a natural allotetraploid (x = 7) with two basic genomes A′ and B. The former is homologous to the genome of the diploid Pearl millet, *P. typhoides* Stapf. & Hubb. (Krishnaswamy & Raman 1951). Consequently, the amphidiploid of the interspecific hybrid between these two species is fertile forming 21 bivalents at meiosis (Krishnaswamy & Raman 1954b). The Napier grass, when pollinated with this amphidiploid, produced two chromosome deficient plants in the progeny. These two plants formed $10_{II} + 4_{I}$ at meiosis and were described as quadruple monosomics. Sterility was also very high in these two deficient plants (Krishnaswamy & Raman 1954a). The cytogenetical studies on the progeny of these monosomes are presented in this paper.

Material and methods

One hundred open-pollinated panicles of the monosomes were harvested. The seeds were sown as fluff since the seeds were

very small and were fully enclosed in the glumes. Setting is very low in the panicles. Four seedlings were raised but only two survived to maturity.

Twenty panicles of the monosomes were pollinated with *P. typhoides*. The seeds were sown as fluff and one plant was raised.

Cytological observations were made from temporary aceto-carmine squashes of anthers fixed in acetic alcohol (1:3).

Observations

Of the two plants raised through open pollination, one was vigorous and tillering heavily. The leaves in the seedling were pigmented. The overall characters of the leaves, stem and panicle were like those of *P. purpureum*. The emergence of the anthers was good and the stigmata exserted well. The chromosome number was found to be $2n = 45$ and the meiosis revealed the following chromosome associations.

Maximum $7_{iv} + 7_{ii} + 3_i$
Minimum $21_{ii} + 3_i$
Mean (of 21 cells) $2 \cdot 6_{iv} + 1 \cdot 3_{iii} + 13 \cdot 6_{ii} + 3 \cdot 6_i$

There were three bivalents and one univalent attached to the nucleolus. Pollen sterility was 81%.

The other plant raised through open-pollination was similar in external morphology to the 45-chromosomed plant but was less vigorous and the emergence of the anthers was not good. The chromosome number was determined to be $2n = 38$ and the meiotic associations were as follows:

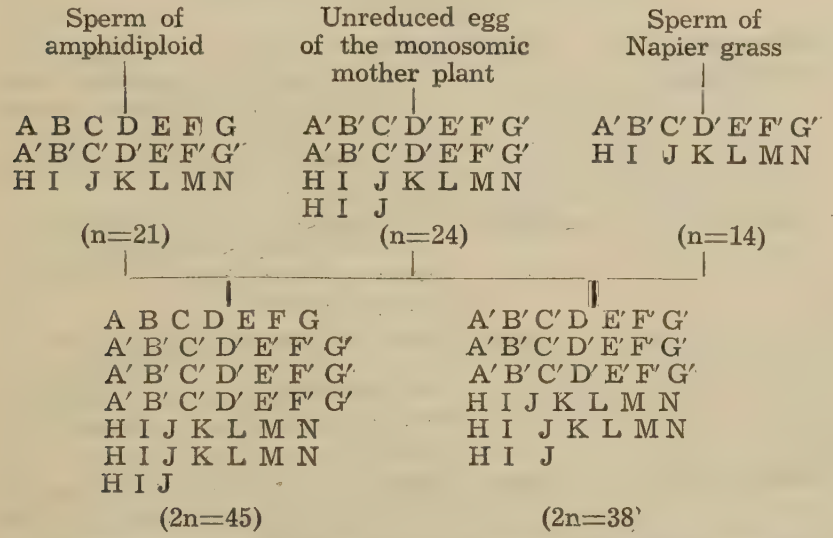
Maximum $7_{iii} + 7_{ii} + 3_i$
Minimum $1_{iii} + 13_{ii} + 9_i$
Mean (of 22 cells) $3 \cdot 8_{iii} + 10 \cdot 2_{ii} + 6 \cdot 2_i$

There were two bivalents and two univalents attached to the nucleolus. Pollen sterility was very high (92%).

The third plant was derived by pollination with *P. typhoides* and resembled its monosomic mother in external morphology, in chromosome number ($2n = 24$) and also in meiotic association forming ten bivalents and four univalents regularly. Two bivalents were nucleolar. Pollen sterility was 96%.

Discussion

The 45 and 38-chromosomed progenies suggest that unreduced female gametes might have functioned in the monosomic mother. In that case, the concerned sperms should have contributed 21 and 14 chromosomes respectively. Since the mother plant was surrounded by normal Napier grass (2n = 28) and also amphidiploid *Pennisetum* (2n = 42, Krishnaswamy & Raman 1954b), it was speculated that by natural cross pollination, these two could have been the male parents of the 38 and 45-chromosomed progenies respectively. The following will then be the constitution of these two progenies :


Sperm of amphidiploid
A B C D E F G
A′ B′ C′ D′ E′ F′ G′
H I J K L M N
(n=21)
Unreduced egg of the monosomic mother plant
A′ B′ C′ D′ E′ F′ G′
A′ B′ C′ D′ E′ F′ G′
H I J K L M N
H I J
(n=24)
Sperm of Napier grass
A′ B′ C′ D′ E′ F′ G′
H I J K L M N
(n=14)
A B C D E F G
A′ B′ C′ D′ E′ F′ G′
A′ B′ C′ D′ E′ F′ G′
A′ B′ C′ D′ E′ F′ G′
H I J K L M N
H I J K L M N
H I J
(2n=45)
A′ B′ C′ D′ E′ F′ G′
A′ B′ C′ D′ E′ F′ G′
A′ B′ C′ D′ E′ F′ G′
H I J K L M N
H I J K L M N
H I J
(2n=38)

The chromosome constitutions of the two progenies suggested above, are capable of forming the observed maximum associations at meiosis.

Krisnaswamy & Raman (1954 a) indicated that one of the four deficient chromosomes of the mother plant appeared to belong to the A′ genome (chromosomes A′-G′). If that is so, it may be noted that the 45-chromosomed progeny cannot form the observed maximum of seven quadrivalents. Therefore the present studies indicate that all the four deficient chromosomes of the mother plant belong only to the B genome (chromosomes H-N).

The 24-chromosomed progeny resembled the mother plant not only in external morphology but also in chromosome number and meiotic association. It may be reasonable to suggest that this

plant might have arisen by apomixis. In the genus *Pennisetum*, apomixis has been suggested in *P. clandestinum*, *P. setaceum*, *P. villosum* and *P. orientale*, all of which are species with the basic chromosome number x = 9 and in *P. ramosum* with the basic number x=5 (Narayan 1954, 1955). But this phenomenon is not yet known in *P. typhoides* and *P. purpureum* which have the basic number x=7. However, apomixis was indicated in the synthetic allotetraploid *Pennisetum* (2n=28; Raman & Krishnaswami 1960). Autotetraploid *P. typhoides* has also been noted to produce diploids in its selfed progeny.

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Ternary Liquid System: Kerosene—Acetone—Water

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ABSTRACT

In connection with mass transfer studies for the etxraction of acetone from aqueous solutions, phase distribution and equilibirum data were required for the system *kerosene*—acetone—water. In the present paper mutual solubility and phase distribution data are given for the ternary system kerosene—acetone—water at 30°C. Tie line data have been correlated by the methods of Othmer—Tobias and Hands.

Introduction

Increasing importance of liquid-liquid extraction as a means of separating liquid components has enhanced the need for mass transfer data for design purposes and a knowledge of reliable phase equilibrium data is essential for such mass transfer studies. Extraction of acetone from aqueous solutions has received recently considerable attention. Phase equilibrium data with solvents like esters, ethers, alcohols, hydrocarbons and halogenated hydrocarbons have been reported in the literature. The present study was undertaken to obtain the equilibrium and tie line data for the kerosene — acetone — water system at 30°C in connection with the study of mass transfer resistance in a continuous countercurrent liquid-liquid extraction column.

Experimental

Materials Used :

Acetone : — Acetone supplied by Government Cordite Factory was redistilled and the fraction boiling at 56·1°C was used. It had a density of 0·7791 gm/$_{cc}$ at 30°C and Refractive index of 1·3541 at 30°C.

Kerosene : — Pure white kerosene was supplied by Burmah-Shell oil distributing Co. It had a density of 0·7740 gm/$_{cc}$ and refractive index of 1·4026 at 30°C.

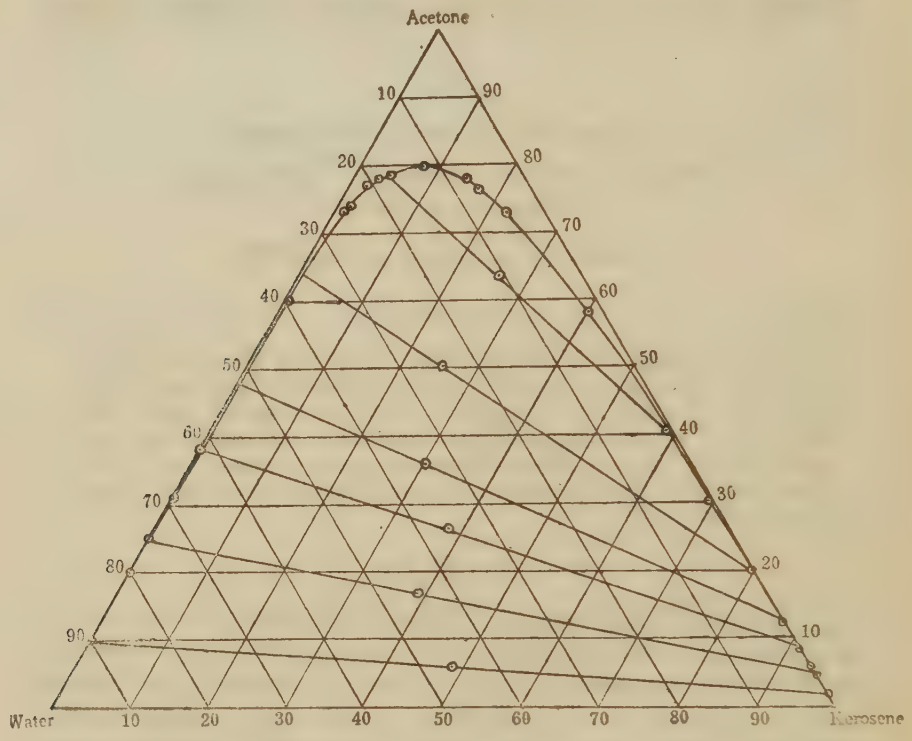

Fig. 1. Kerosene—Acetone—Water System

Water :—Distilled water from laboratory supply was used.

Experimental Procedure : —

Determination of the limiting solubility and the tie-lines in the ternary system at 30°C was made by the method described by Othmer et al (1941, 1942). Mixtures of acetone and water or acetone and kerosene of known concentration were held in a water bath at 30° ± 0·1°C and were titrated with the third component until the appearance of turbidity indicating the limiting solubility concentration. To determine the tie lines, known mixtures of such composition within the two phase region were prepared and agitated in the water bath for a minimum period of four hours. When the two separated phases were clear, the individual phases were separated and weighed. The composition of each phase was

evaluated by the solution of the necessary material balance relations, taking advantage of the fact that these must lie on the equilibrium curve. The extremities of the tie lines thus determined

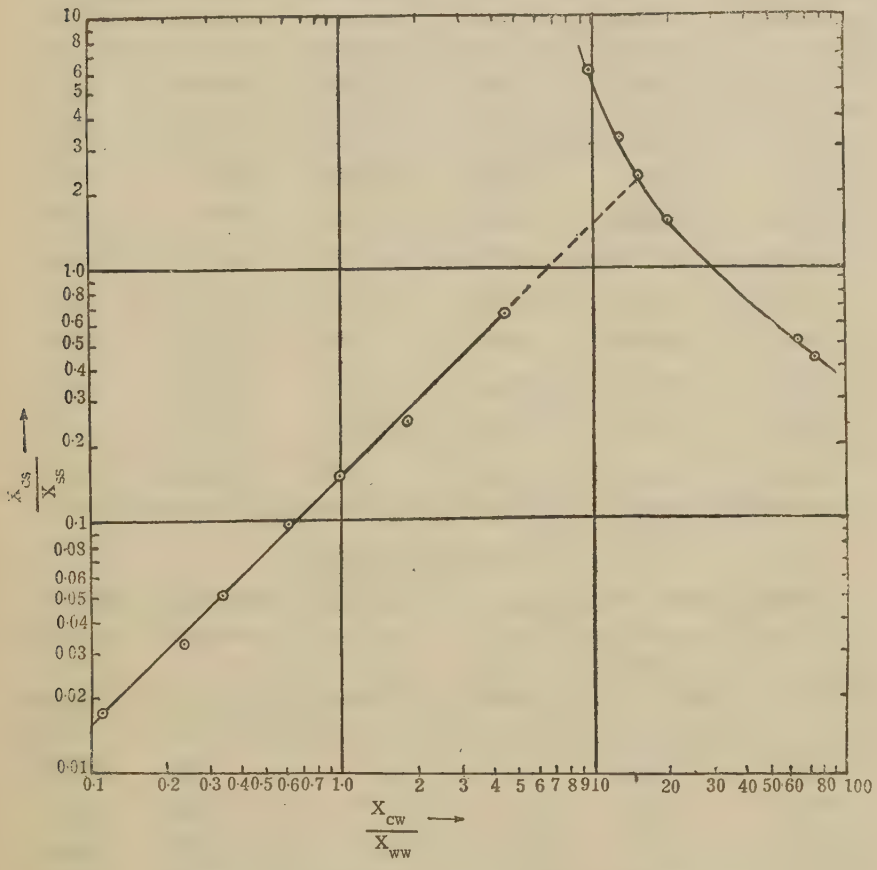

Fig. 2. Hands Plot of Tie Line Correlation

were also checked by determining the acetone content of each layer volumetrically by the method given by M. Morasco (1926).

Results and Correlations:

The solubility and the tie line data for system, kerosene—acetone—water are given in Table I. The binodal curve for the same system is plotted in Fig. 1. Plait point has been determined for the system by the method suggested by Treybal, Weber and Daley (4). This has been shown in Fig. 2 where on the plot of

TABLE I

Equilibrium Data for the System: Kerosene-Acetone-Water at 30°C
Mutual Solubility Data: Weight percentage

Kerosene	Acetone	Water	Kerosene	Acetone	Water
0·0	9·91	90·09	90·06	9·94	0
0·0	14·71	85·23	79·79	20·01	0·2
0·2	19·92	79·88	69·60	30·0	0·4
0·4	39·65	59·95	59·20	40·0	0·8
0·44	29·77	69·79	39·20	57·9	2·9
0·77	49·30	49·93	28·4	67·3	4·3
0·80	73·00	26·20	21·8	72·3	5·9
2·0	77·0	21·0	16·2	75·7	8·1
3·0	78·0	19·0	14·7	77·3	8·0
4·3	78·9	16·80	8·0	80·3	11·7

Tie-line data at 30°C

Water phase composition:			Kerosene phase composition:		
	wt %			wt %	
Water	Acetone	Kerosene	Water	Acetone	Kerosene
99·16	0·84	0	0	·125	99·875
97·90	2·10	0	0	·320	99·68
96·50	3·5	0	0	·55	99·45
95·25	4·75	0	0	·73	99·27
90·0	10·0	0	0	1·67	98·33
81·8	18·0	0·2	0	3·2	96·8
74·5	25·10	0·4	0	4·78	95·22
61·2	38·4	0·4	0·2	8·7	91·1
51·3	48·00	0·7	0·2	12·5	87·3
35·0	64·2	0·8	0·2	20·0	79·8
17·5	78·5	4·0	0·8	39·7	59·5

$\frac{Xcs}{Xss}$ Vs $\frac{Xcw}{Xww}$ giving the tie line correlation according to Hand,, the limiting solubility curve is also plotted as $\frac{Xc}{Xs}$ Vs $\frac{Xc}{Xw}$. As at the plait point the distinction between the water rich layer and solvent rich layer vanishes, the intersection of the tie line correlation with the limitig solubility curve represents the plait point for the system. The plait point thus established is 67·3 % acetone, 4·3 % water and 28·4 % kerosene.

Figures 3 indicates the distribution of acetone in aqueous layer and kerosene layer. In order to compare the selectivity of

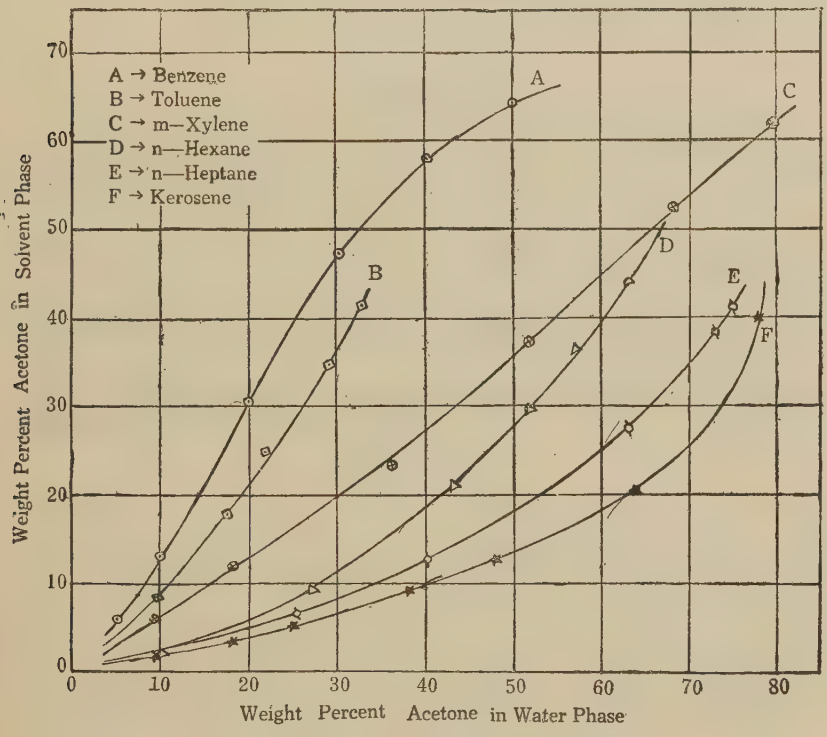

Fig. 3. Equilibrium Distribution Diagram

hydrocarbons as solvent for the extraction of acetone from aqueous solutions distribution curves have also been drawn in the same figure for the straight chain hydrocarbons, n Hexane, n-Heptane and aromatic hydrocarbons benzene, toluene and m-xylene. It is observed that as the molecular weight of the hydrocarbon in the

homologous series increases, the selectivity of the solvent for the extraction of acetone decreases.

Notation

Xcs : weight fraction of acetone in solvent layer.

Xcw : weight fraction of acetone in water layer.

Xss : weight fraction of solvent in solvent layer.

Xww : weight fraction of water in water phase.

Xc : weight fraction of acetone.

Xs : weight fraction of solvent.

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Liquid-Liquid Extraction—Extraction of Acetone from Aqueous Solutions by Kerosene in 2" I.D. Packed Counter Current Extraction Column

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ABSTRACT

Mass transfer data have been determined for the extraction of acetone from aqueous solution with kerosene as the solvent in a 2" i.d. packed column using ¼" and ⅜" Raschig rings, ¼" and ⅜" Lessing rings, ¼" Berl saddles and ¼" spheres. Results expressed as overall mass transfer coefficient $K_C a$ and $K_D a$ have been analysed for the effect of the flow rates of the continuous and discontinuous phases. The column was operated in such a manner as to have the direction of solute transfer from the continuous aqueous phase to discontinuous solvent phase. The individual 'Height of Transfer Units' $(HTU)_c$ and $(HTU)_d$ have been isolated from the overall (HTU) data by the method suggested by Colburn.

Introduction

Liquid-liquid extraction has recently achieved an important position as a means of separation of liquid mixtures in a wide variety of chemical industries. Although a variety of extraction equipment is now available involving means to enhance the two phase contact, the packed column remains one of the most widely used equipments in commercial practice. It is recognised that limiting flow rates and mass transfer rates govern the diameter and height respectively of the packed liquid-liquid extraction columns. The limiting flow rates have been investigated by Breckenfeld et al (1950), Dell & Pratt (1951), Ballard and Piret (1950), Venkataraman (1959) etc., and can now be predicted with some degree of confidence. However, performance data on mass transfer rates are not easily available and pilot plant runs have to be carried out for each extraction problem. Extraction of acetone

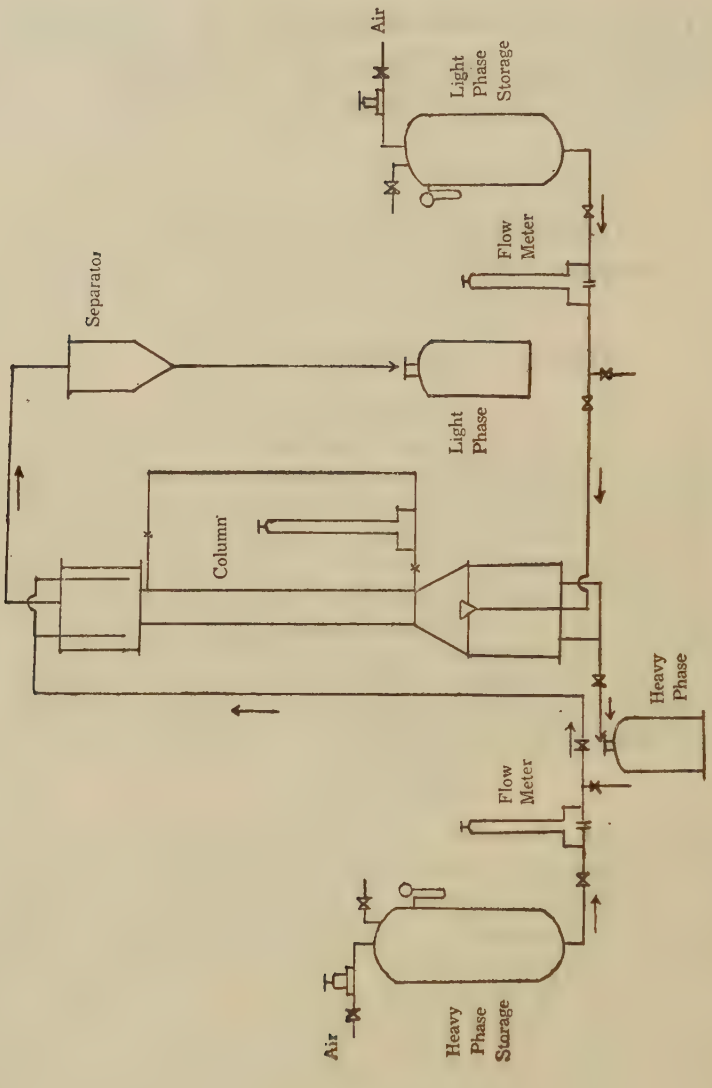

FIG. 1. Experimental set up

from aqueous solution has recently received considerable attention. Gayler and Pratt (1957) presented mass transfer data with butyl acetate, ethyl acetate, toluene and chlorex as solvents. Some data are also available for extraction of acetone from aqueous solutions in spinner columns, rotary annular columns, pulsed columns etc. (1957). Present data on mass transfer rates for the extraction of acetone from aqueous solution by kerosene in a 2″ packed tower using Raschig rings, Berl saddles, Lessing rings and spheres were taken in connection with the research programme of estimating the influence of packing characteristics and physical properties of liquid systems on overall mass transfer co-efficients and mass transfer resistances.

Experimental

Apparatus:

The extraction column used in the present investigation was a 2″ i.d. pyrex glass tube, 3 feet in length fitted with expanded end pieces, 6″ i.d. at the bottom and 4½″ i.d. at the top. The bottom end piece was made of a truncated cone mounted on a cylindrical end piece. The cylindrical portions of the end pieces were provided with a pair of sight glasses at diametrically opposite ends and also with outlet and inlet connections. Both the ends of the glass column were fastened to the respective headers by means of flanges and neoprene gaskets. The conical section at the bottom was also fitted with sight glasses to observe the column behaviour near the packing support and distributor. A distributor having 40 holes of 1/16″ diameter was used to disperse the light phase liquid. A schematic flow diagram of the experimental set up is shown in Fig. 1.

Packings Used:

¼ Raschig rings and ¼″ Berl Saddles made of unglazed porcelain were supplied by Maurice A. Knight, Ohio. ¼″ Lessing rings of unglazed porcelain were supplied by Hydronyl Syndicate Ltd., London. ¼″ glass spheres were purchased locally. The nominal and actual dimensions of these packing materials along with the physical characteristics 'a' and 'e' are listed in Table-I. In calculating 'a', the superficial area of the packing, the wetted area of the column was also included.

Materials Used:

Kerosene was supplied by Burmah-Shell Oil Storage and Distributing Co. of India Ltd. Acetone was supplied by Govt.

TABLE I

Packing Characteristics

Packing	Outside diameter in inches	Inside diameter in inches	Length	a	e
3/8" Raschig rings ..	0·365	0·194	0·363	158·2	0·632
1/4" Raschig rings ..	0·250	0·123	0·245	206·0	0·58
3/8" Lessing rings ..	0·380	0·252	0·374	185·0	0·635
1/4" Lessing rings ..	0·254	0·187	0·249	283·0	0·690
1/4" Berl Saddles ..	..	..	..	223·0	0·650
1/4" Spheres ..	0·252	..	..	192·7	0·464

Cordite Factory, Aruvankadu. The physical properties of the solvent phase and aqueous phase, viz., density, viscosity and interfacial tension were determined at 30°C and are reported in Table-II. Ostwald type of viscometer, B.S.S. No. 188, size I, was used to determine the viscosity of the solutions and Du Nüoy Tensiometer supplied by Fischer Scientific Company, U.S.A., was employed for finding the values of interfacial tension.

TABLE II

Physical properties of Liquid Phases at 30°C

Phase	Density gm/cc	Viscosity centipoises	Tension Interfacial dynes/cms
Aqueous Phase ..	0·9982	0·807	
			24·52
Kerosene Phase ..	0·7816	1·18	

Phase Equilibrium Data :

Phase equilibrium data for the system Acetone-water-Kerosene at 30°C essential for the mass transfer studies were determined at 30°C and are presented in Fig. 2.

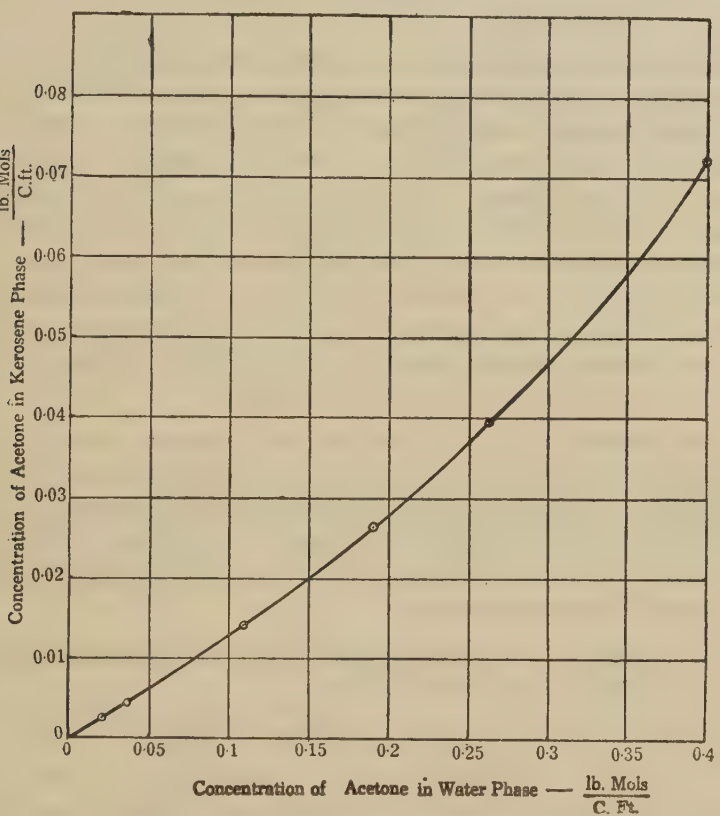

Fig. 2. Equilibrium Distribution Diagram

Experimental Procedure :

Operation of the tower for determining mass transfer rates consisted of first making up feed solutions of the desired solute concentrations. In order to ensure that each feed solvent was saturated with the other, a layer of water was maintained on the bottom of the solvent layer in the solvent feed tank and a layer of solvent on the top of the fluid in the aqueous feed tank. Feed flow of both phases was motivated by means of constant air pressure provided from a 25 lb/sq″ gauge air source. The high pressure air line was connected to the feed tanks through

a pressure regulator set at 5 lbs/sq" gauge. The column was filled with continuous phase and the rate adjusted to the desired value as observed by the manometer provided with the orifice which was calibrated directly. The dispersed phase flow was next turned on and brought up to the desired rate, the interface position being stabilised at the same time in the middle of the separating section. When conditions appeared to be steady, readings were taken of the solvent and aqueous flow rates, the column pressure drop, the inlet and outlet temperatures and the interface position. Such experimental data were recorded only when the total contents of the column had been changed at least 3 to 4 times, care being taken to maintain the interface level constant throughout this period for obtaining the steady state. The exit phase flow rates were then measured directly and samples were taken of the inlet and exit flows for analysis. It was essential that the operating conditions remained steady during sampling and this was checked by inlet flow rates from the respective orifice meters.

The samples were analysed for the acetone content by the hydroxylamine method (1926). Material balances for solute were made for the solvent kerosene and diluent water phases for each run and any run showing a discrepancy greater than ± 5 % was discarded as this was presumably due to unsteady state and the run repeated for steady state.

The mass transfer data may be interpreted using the following form of the basic rate equation:

$$dN = K_c a \ (C_c - C_c^*) \ dv = K_D a \ (C_D^* - C_D) \ dV \quad .. \quad (1)$$

This can be integrated on the assumptions: (i) the equilibrium and operating lines were straight i.e., moles of each liquid solvent remain constant throughout the column; (ii) concentrations are relatively dilute, (iii) $K_C a$ and $K_D a$ are also constant throughout the column.

Then, the following relationships result:

$$N_A = K_c a \ V(\triangle C_c)_{lm} = K_D a \ V(\triangle C_d)_{lm} \quad .. \quad (2)$$

where

$$(\triangle C_c)_{lm} = \frac{(C_{c,1} - C^*_{c,1}) - (C_{c,2} - C^*_{c,2})}{2{\cdot}3 \log \frac{(C_{c,1} - C^*_{c,1})}{(C_{c,2} - C^*_{c,2})}} \quad .. \quad (3)$$

$$\text{and } (\triangle C_d)_{lm} = \frac{(C^*_{d,1} - C_{d,1}) - (C^*_{d,2} - C_{d,2})}{2{\cdot}3 \log \frac{(C^*_{d,1} - C_{d,1})}{(C^*_{d,2} - C_{d,2})}} \quad .. \quad (4)$$

Elgin and Browning (1935) mentioned that for all practical purposes, use of this simple equations is sufficiently close to the correct value. The total amount of solute transfer per hour i.e., N may be computed from data on either phase as indicated below :

$$N_c = Uc \ (S) \ (C_{c,1} - C_{c,2}) \quad .. \quad (5)$$

$$N_D = U_D \ (S) \ (C_{d,1} - C_{d,2}) \quad .. \quad (6)$$

$$N_A = \frac{N_C + N_D}{2}$$

Average value of Nc and N_D is used for calculating mass transfer coefficients. Incidentally use of equations (5) and (6) provide a means for checking the overall solute material balance for an experimental run.

$(HTU)_{OC}$ and $(HTU)_{OD}$ were determined from the equations:

$$(HTU)_{OC} = \frac{U_c}{K_C a} \quad .. \quad (6)$$

$$(HTU)_{OD} = \frac{U_D}{K_D a} \quad .. \quad (7)$$

Results and Correlations of Data:

A few typical calculated mass transfer data are presented in Table III.

TABLE III

Mass Transfer Data

Packing: ⅜″ Raschig Rings

Temperature: 28°C — 30°C

Experiment No.	U_D	U_C	$\frac{U_C}{mU_D}$	$\frac{mU_D}{U_C}$	K_Ca	$(HTU)_{OC}$	K_Da	$(HTU)_{OD}$
1	11·0	10·5	7·95	0·125	0·73	14·4	6·05	1·82
2	30·7	„	2·85	0·35	1·88	5·6	15·70	1·96
3	49·2	„	1·77	0·56	2·76	3·8	22·8	2·16
4	8·2	23·4	23·8	0·042	0·57	41·2	9·75	1·85
5	13·9	„	14·0	·0715	0·93	25·0	7·50	1·77
6	30·7	„	6·35	0·15	1·97	11·9	16·6	1·85
7	41·2	„	4·75	0·21	2·50	9·35	21·00	1·96
8	10·5	9·0	7·15	0·141	0·73	12·3	6·10	1·725
9	„	27·3	21·6	·046	·74	37·0	6·15	1·71
10	„	40·7	32·2	·031	·70	57·9	5·90	1·78
11	21·3	10·3	4·03	0·247	1·33	7·65	11·45	1·88
12	—	19·2	7·50	0·132	1·37	13·9	11·55	1·85
13	—	29·3	11·5	·087	1·38	21·2	11·35	1·85
14	—	40·2	15·7	·063	1·36	29·8	13·10	1·62

Packing: ¼" Raschig Rings
Temperature: 30·5°C — 31°C

Experiment No.	U_D	U_C	$\frac{U_C}{mU_D}$	$\frac{mU_D}{U_C}$	K_Ca	$(HTU)_{OC}$	K_Da	$(HTU)_{OD}$
15	7·5	8·0	8·9	·112	0·62	12·9	5·13	1·46
16	14·9	„	4·47	·223	1·26	6·35	10·2	1·41
17	20·7	„	3·22	·310	1·50	5·24	13·2	1·57
18	28·4	„	2·34	·425	2·00	4·0	17·2	1·65
19	7·2	20·2	23·4	·042	·62	32·2	5·25	1·37
20	10·4	„	16·3	·062	0·86	23·5	7·25	1·43
21	13·2	„	12·7	·078	1·12	18·0	9·4	1·40
22	17·2	„	9·8	·102	1·42	14·25	11·7	1·47
23	8·7	8·2	7·85	·127	·73	11·2	6·15	1·41
24	„	20·7	19·8	·05	·75	27·4	6·45	1·35
25	„	30·7	29·3	·034	·79	38·6	6·5	1·34
26	„	45·2	43·5	·023	·73	61·5	6·1	1·42
27	11·7	8·2	5·85	·172	·95	8·65	7·8	1·50
28	„	17·2	12·3	·081	1·0	17·2	8·25	1·41
29	„	26·7	19·0	·052	1·025	26·0	8·35	1·40
30	„	33·0	23·5	·042	1·0	33·0	8·32	1·40

Packing: ⅜″ Lessing Rings

Temperature: 28°C — 29·5°C

Experiment No.	U_D	U_C	$\frac{U_C}{mU_D}$	$\frac{mU_D}{U_C}$	K_Ca	$(HTU)_{OC}$	K_Da	$(HTU)_{OD}$
31	10·7	16·2	12·6	·079	0·8	20·2	6·65	1·61
32	32·7	„	4·13	·242	2·34	6·92	19·3	1·69
33	62·7	„	2·16	·465	3·6	4·5	38·0	1·65
34	87·1	„	1·55	·644	5·65	2·87	47·5	1·83
35	10·2	36·7	30	0·033	·815	45·0	6·75	1·51
36	21·7	„	14·1	·071	1·54	23·7	13·7	1·58
37	39·7	„	7·7	·13	2·8	13·1	23·6	1·68
38	50·2	„	6·09	·164	3·56	10·3	29·3	1·71
39	13·4	9·7	6·05	·166	0·92	10·55	8·12	1·65
40	„	32·7	20·3	·049	1·03	31·8	8·6	1·56
41	„	67·2	41·5	·029	·99	68·0	8·4	1·59
42	37·1	10·9	2·46	·41	2·42	4·5	20·2	1·835
43	„	21·7	4·9	·204	2·69	8·15	22·6	1·64
44	„	40·5	9·1	·11	2·69	15·0	22·6	1·64
45	„	45	10·1	·099	2·64	17·05	22·0	1·68

Packing: ¼″ Lessing Rings

Temperature: 29°C — 30·5°C

Experiment No.	U_D	U_C	$\frac{U_C}{mU_D}$	$\frac{mU_D}{U_C}$	K_Ca	$(HTU)_{OC}$	K_Da	$(HTU)_{OD}$
46	9·2	9·8	8·85	·113	·825	11·8	6·85	1·34
47	„	19·2	17·35	·057	·86	22·4	6·98	1·315
48	„	29·3	26·5	·037	·841	34·8	6·91	1·34
49	„	46·1	42·0	·023	·75	61·6	6·35	1·45
50	20·7	10·2	4·1	·244	1·86	5·47	15·5	1·335
51	„	16·3	6·55	·153	1·915	8·5	15·8	1·31
52	„	23·9	9·60	·104	1·975	12·1	16·5	1·25
53	„	35·0	14·1	·071	1·915	18·5	15·8	1·31
54	8·1	12·5	12·9	·077	·88	14·2	7·4	1·09
55	39·2	„	2·65	·377	3·5	3·57	30·1	1·30
56	50·2	„	2·07	·483	4·1	3·0	33·6	1·49
57	10·2	17·8	14·5	·069	·945	18·75	7·9	1·29
58	21·2	„	7·0	·143	2·04	8·75	17·1	1·235
59	34·2	„	4·34	·23	2·88	6·2	23·8	1·435
60	54·0	„	2·75	·363	4·1	4·35	34·2	1·58

Packing: ¼" Berl Saddles

Temperature: 27·5°C-29°C

Experiment No.	U_D	U_C	$\frac{U_C}{mU_D}$	$\frac{mU_D}{U_C}$	K_Ca	$(HTU)_{OC}$	K_Da	$(HTU)_{OD}$
61	8·8	11·1	10·55	·094	·75	14·7	7·18	1·23
62	22·7	„	4·06	·244	1·975	5·6	16·1	1·41
63	32·1	„	2·83	·346	2·76	4·02	22·9	1·40
64	52·0	„	1·78	·565	3·76	2·95	30·8	1·67
65	10·5	25·2	20·0	·05	1·03	24·5	8·7	1·365
66	16·7	„	12·6	·08	1·74	14·5	13·1	1·275
67	30·3	„	6·75	·144	2·85	8·95	21·8	1·39
68	35·2	„	5·95	·168	3·10	8·15	24·6	1·43
69	11·1	10·2	7·65	·131	1·025	9·95	8·4	1·32
70	„	25·0	18·7	·054	1·045	24·0	8·6	1·29
71	„	42·0	31·6	·031	1·04	40·4	8·65	1·28
72	„	53·2	40·0	·025	0·94	56·2	7·95	1·41
73	16·2	9·7	5·0	·20	1·37	7·06	11·25	1·44
74	„	22·7	11·65	·086	1·49	15·25	12·4	1·31
75	„	50·2	25·8	·038	1·52	33·0	12·55	1·29

Packing: ¼" Spheres

Teperature: 27·5-28°C

Experiment No.	U_D	U_C	$\frac{U_C}{mU_D}$	$\frac{mU_D}{U_C}$	K_Ca	$(HTU)_{OC}$	K_Da	$(HTU)_{OD}$
76	9·0	8·7	8·05	·124	·692	12·65	5·7	1·58
77	16·4	„	4·45	·225	1·275	6·82	10·6	1·54
78	24·5	„	2·96	·337	1·69	5·14	14·1	1·74
79	36·5	„	1·98	·505	2·61	3·33	21·5	1·70
80	9·5	20·2	17·7	·056	·773	26·2	6·5	1·46
81	12·3	„	13·75	·073	·945	21·4	7·8	1·58
82	15·7	„	10·7	·093	1·28	15·7	10·65	1·48
83	25·0	„	6·65	·149	1·92	10·5	15·8	1·58
84	8·75	7·25	6·86	·145	·68	10·65	5·65	1·55
85	„	17·5	16·6	·06	·73	24·9	6·00	1·46
86	„	28·5	27·2	·036	·73	39·1	6·7	1·30
87	„	33·7	32·0	·031	·715	47·2	5·94	1·49
88	23·2	10·2	3·65	·274	1·72	5·92	14·1	1·64
89	„	14·3	5·15	·194	1·83	7·8	15·4	1·55
90	„	22·0	7·95	·126	1·89	11·6	15·7	1·47

Since the overall mass-transfer co-officient $K_C a$ is very sensitive to fluctuations in flow rates, $K_C a$ has been plotted on cartesian coordinates for ¼″ Berl saddles in Fig. 3 against dis-

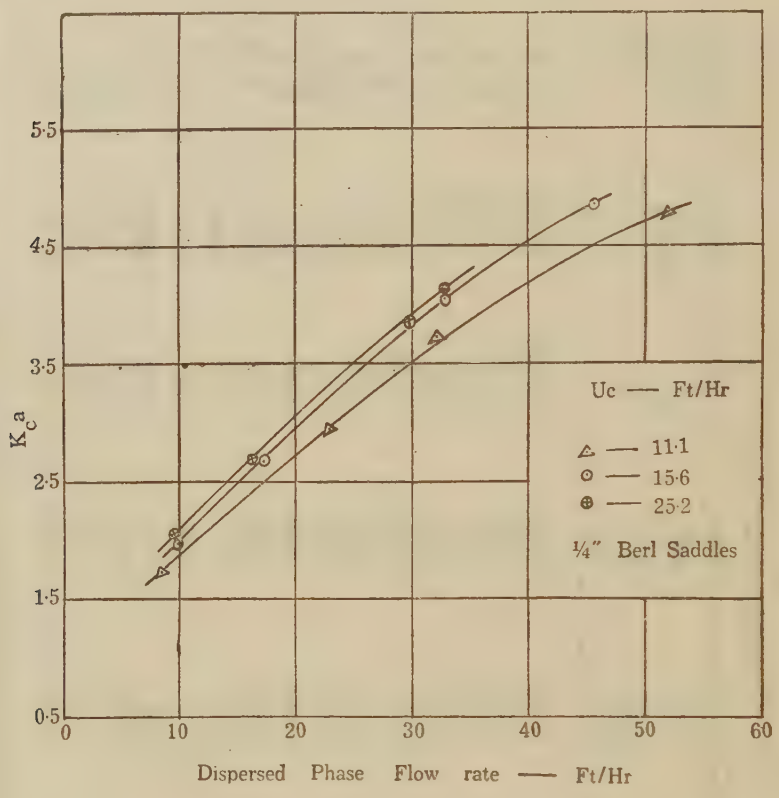

Fig. 3. Effect of Dispersed Phase Flow Rate on $K_C a$

continuous phase flow rate and for ¼″ spheres Fig. 4 shows the plot of $K_C a$ against continuous phase flow rate. Similar plots are obtained if $K_D a$ is plotted against U_D or U_C. It is observed from the diagrams that $K_C a$ is more dependent on dispersed phase flow rates as compared to continuous phase flow rates. These plots also indicate that no straight line relationship exists between $K_C a$ with U_c or U_D.

Incidentally it may be noted that the graphical representation of $K_C a$ values against dispersed phase flow rate gives a better

presentation of column operation for mass-transfer studies, since $K_C a$ values should be zero at U_D equal to zero. This correlation

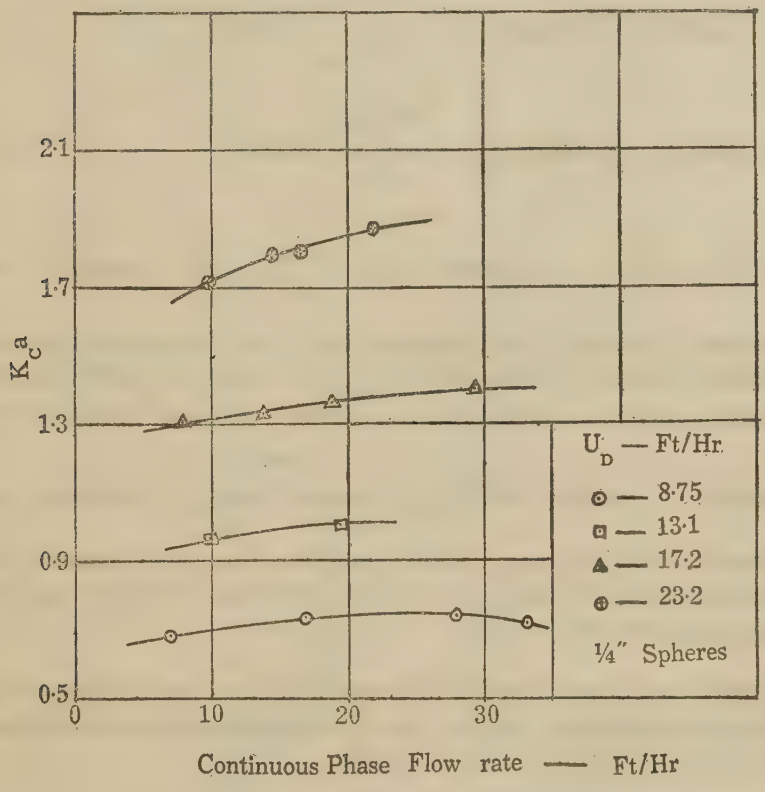

Fig. 4. Effects of Continuous Phase Flow Rate on $K_C a$

therefore offers a guide to extrapolating the values of $K_C a$ at lower values of U_D.

Individual 'Height of Transfer Units':

In order to understand the mechanism of mass transfer an attempt was made to isolate the individual mass transfer resistances from the mass transfer data.

A. P. Colburn (1939) has indicated that the overall 'Height of Transfer Units' can be expressed in terms of individual 'Height

of Transfer Units' in liquid-liquid extraction as in the case of gas absorption practice.

$$(HTU)_{OC} = (HTU)_C + \frac{U_c}{m\ U_D} (HTU)_D \quad .. \quad (8)$$

$$(HTU)_{OD} = (HTU)_D + \frac{m\ U_D}{U_c} (HTU)_C \quad .. \quad (9)$$

If $(HTU)_{OC}$ is plotted against $\frac{U_c}{m\ U_D}$ in cartesian co-ordinates a straight line is obtained as a first approximation, the intercept of which on the $(HTU)_{OC}$ axis represents $(HTU)_C$ and the slope of the line represents $(HTU)_D$ These values can be checked by plotting $(HTU)_{OD}$ against $\frac{m\ U_D}{U_c}$ in cartesian co-ordinates for the same packing and for the same system, the intercept of the straight line obtained represents $(HTU)_D$ and the slope gives $(HTU)_C$ value.

However in practice the intercept and slope are only generally indicative of the film values. In order for them to be true values, the following conditions must be met.

1. The equilibrium line is straight, that is $m = \frac{dC_d}{dC_c}$ = constant. This condition is generally true in dilute solutions.

2. The operating line is straight i.e., the volumetric rate of each solvent phase is constant throughout the column.

3. The individual film transfer units are constant and do not vary with flow rates, solute and solvent concentrations in the column.

The first two conditions are easily met by proper choice of system and concentration. The validity of the third condition must be tested experimentally.

Several investigators have correlated their experimental data on $(HTU)_{OC}$ and $(HTU)_{OD}$ by plotting these values against $\frac{U_c}{mU_D}$ and $\frac{m\,U_D}{U_C}$ respectively on cartesian co-ordinates and ob-

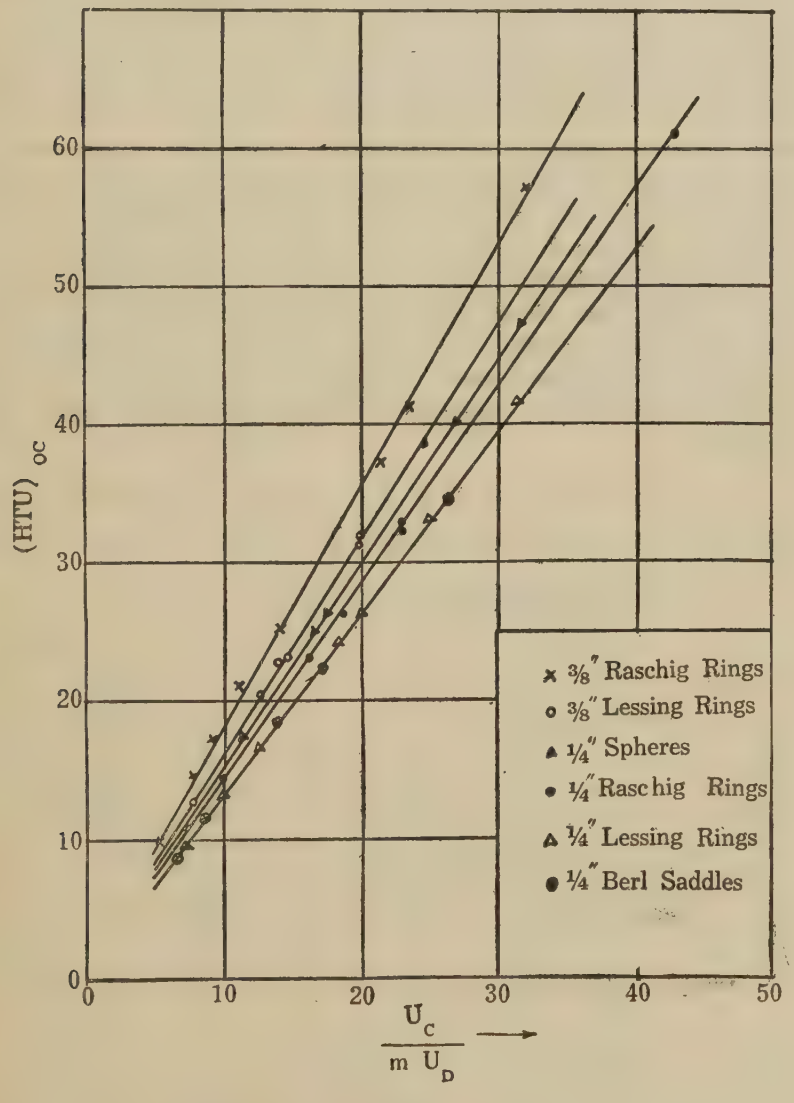

FIG. 5. Effect of $\frac{U_C}{mU_D}$ on $(HTU)_{OC}$

tained straight line correlation as required by the equations derived by Colburn (5) assuming that $(HTU)_c$ and $(HTU)_D$ are essentially independent of the phase flow rates. However, this is partly contradictory to the fundamental studies on the individual mass transfer resistances carried out by Colburn and Welsh (1942) Laddha and Smith (1950) and Gayler and Pratt (1953) who have shown experimentally that for spray and packed columns, though $(HTU)_D$ is essentially independent of the phase flow rates, $(HTU)_C$ is a function of the phase flow rates. These investigators have, however, used binary systems in packed and spray columns contacting two pure liquids of limited solubility in each other in the absence of a 3rd solute and the approach to saturation of each phase was expressed in terms of the individual transfer units. In all these cases diffusion is two-directional i.e., each liquid is diffusing into the other simultaneously till saturation occurs. In the case of a ternary system involving transfer of solute either from the continuous phase to the dispersed phase or from the dispersed phase to the continuous phase, diffusion is only unidirectional.

The experimental values on $(HTU)_{OC}$ and $(HTU)_{OD}$ are plotted in Fig. 5 and 6 respectively for all the packings. As seen

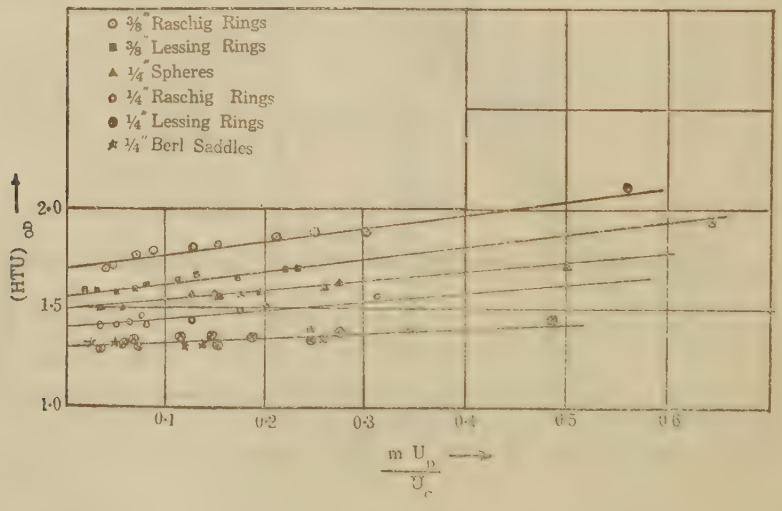

FIG. 6. Effect of $\frac{mU_D}{U_C}$ on $(HTU)_{OD}$

from the figures, it may be observed that Colburn method of plot for $(HTU)_{OC}$ and $(HTU)_{OD}$ has been well satisfied for all the cases. Positive values of the slope and intercept have been obtained in all the cases. The relationship between $(HTU)_{OC}$ and corresponding $(HTU)_{OD}$ plots, assuming individual (HTU) values are relatively independent of flow rates is that the slopes of the line in the plot of $(HTU)_{OC}$ against $\frac{U_c}{mU_D}$ become the intercepts of the lines in the plot of $(HTU)_{OD}$ against $\frac{mU_D}{U_c}$ and conversely, the intercepts of the lines of the first type of plot become the slopes of the second type of plot. This condition is verified within the limits of experimental error. All the experimental points have been numerically analysed by the method of least squares and the constant $(HTU)_C$ and $(HTU)_D$ have been evaluated in each case and presented in Table IV.

TABLE IV

Individual Transfer Units

Packing	$(HTU)_C$	$(HTU)_D$
3/8" Raschig rings	0·725	1·71
3/8" Lessing rings	0·655	1·54
1/4" Raschig rings	0·415	1·41
1/4" Spheres	0·505	1·49
1/4" Lessing rings	0·256	1·29
1/4" Berl Saddles	0·252	1·30

Conclusion:

Mass transfer data in connection with the extraction of acetone from aqueous solution by kerosene have been analysed to obtain individual heights of transfer units for continuous and discontinuous phases. It is observed from the data of present investigation

that $(HTU)_c$ and $(HTU)_D$ values are independent of continuous and discontinuous phase flow rates and depend only on the packing characteristics and physical properties of the liquid systems.

Acknowledgement:

The authors wish to express their deep gratitude to the University of Madras for the award of a research studentship for carrying out this investigation.

NOMENCLATURE

a	=	Superficial area of contact of phases in packed liquid extraction column	— sq. ft / cft
C	=	Concentration of solute	— lb. mols / cft
C_e^*	=	Concentration of solute in aqueous phase in equilibrium with solvent phase	— lb. mols / cft
C_e	=	Concentration of solute in aqueous phase	— lb. mols / cft
C_D	=	Concentration of solute in solvent phase	— lb. mols / Cft
C_D^*	=	Concentration of solute in solvent phase in equilibrium with aqueous phase	— lb. mols / Cft
$(\triangle C)_{lm}$	=	log.mean driving force	— lb. mols / Cft
$(HTU)_C$	=	Individual 'Height of Transfer Unit' based on continuous phase	— ft.
$(HTU)_D$	=	Individual 'Height of Transfer Unit' based based on dispersed phase.	— ft.
$(HTU)_{OC}$	=	Overall Height of Transfer Unit based on continuous phase	— ft.
$(HTU)_{OD}$	=	Overall Height of Transfer Unit based on dispersed phase	— ft.
K_Ca	=	Overall mass transfer coefficient based on continuous phase	— lb. mols / hr. cft ($\triangle$ C)
K_Da	=	Overall mass transfer coefficient based on dispersed phase	— lb. mols / hr. cft ($\triangle$ C)

$m = \frac{dC_D}{dC_c}$ = Distribution Coefficient at equilibrium

N_c = Amount of solute transferred from aqueous phase — lb. mols / hr.

N_D = Amount of solute transferred to solvent phase — lb. mols / hr.

S = Cross sectional area of the extraction column — sq. ft.

U = Velocity of the aqueous or solvent phase based on the empty cross-section of the column — ft / hr

V = Effective volume of the packed section in the tower — cft.

e = Fractional voidage of packing

SUBSCRIPTS

C — Continuous phase

d — Dispersed phase

1, 2 — Upper and lower positions of the columns respectively.

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ANNUAL REPORT AND RÉSUMÉ

We have much pleasure in presenting the first account of the Annual Report and résumé of the research activities of members of the University Research Scholars' Association and the research activities of our former members. The decision to print this in the Journal of the Madras University, Sections A and B by the University has been a most welcome one and we now look forward to presenting every year these reports. It is my duty to thank our President and Vice-Chancellor, Dr. A. Lakshmanaswami Mudaliar, M.D., D.Sc., D.C.L., D.Litt., F.R.C.O.G., F.A.C.S., for permitting this Association to have its Annual Report printed in the Journal of the Madras University.

Madras
13—10—1959

T. S. SADASIVAN,
Vice-President,
Research Scholars' Association.

ANNUAL REPORT OF THE RESEARCH SCHOLARS' ASSOCIATION

Mr. President Sir, Dr. Nayudamma, Ladies and Gentlemen,

I deem it a privilege to present before you the report of the activities of the Association during the academic year 1958-59.

This Association was established in 1936 with just a handful of members with these objectives:—

(1) to invite distinguished scholars and savants to address the members of the Association;

(2) to take advantage of the Association by using it as a forum for free and frank discussions on problems of common as well as topical interest; and

(3) to provide as many opportunities as possible for social contacts between the members of the various departments of the University by arranging meetings, picnics, excursions, etc.

It is a matter of gratification to note that the Association has grown up gradually over the years and that its present strength is fifty-three.

The inaugural function of this Association was performed on November 25, 1958. Mr. Arthur Isenberg, Technical Adviser to the Southern Languages Book Trust, was the Chief Guest of the evening and he spoke on "Research and the problem of Access to information". Our President, Dr. A. Lakshmanaswami Mudaliar, M.D., D.Sc., D.C.L., D.Litt., F.A.C.S., F.R.C.O.G., Vice-Chancellor, took the chair. The Vice-President, Professor T. S. Sadasivan, Director, Botany Laboratory, welcomed the gathering.

The U. N. O. Day was celebrated under the auspices of the Association on October 24, 1958. A special symposium was arranged on the subject "To Live together in peace as good neighbours". Our Vice-President presided. Professor R. Bhaskaran, T. M. P. Mahadevan and Drs. Devasenapathy and K. V. Sri Ram were kind enough to participate in the symposium.

Another meeting of the Association was arranged in honour of Professor Nguyen Khank Toan, Vice-Minister of Education, of

the Democratic Republic of Viet-Nam on February 7, 1959 with our Vice-President in the chair.

Just a week later, we were fortunate in having in our midst our Minister for Defence, Sri. V. K. K. Menon, in whose honour, a general meeting was held on Saturday the 14th of February, 1959. Our Vice-President presided. In the course of his speech, the Hon'ble Krishna Menon expressed the hope that the scholars would go beyond their special disciplines so that they might develop attitude of enquiry. A number of questions by our Vice-President, Professor George Kurian, Shri T. P. Subromanyam, our Secretary, Sri. K. P. K. Shetty, Sri. P. K. Kartha and others were answered by our distinguished guest.

In conformity with the social objective of the Association a picnic to a place called "Covelang", a health resort very near Madras, was arranged on December 14, 1958, in which about twenty members including our Vice-President took part. For many of us who are forcibly accustomed to the dullness and drudgery, which are the twin inevitable concomitants while working inside the libraries and laboratories, the comparatively calm, congenial and contemplative atmosphere that prevailed at Covelang constituted a source of relaxation and it shall remain ever green in the memory of the participants.

I wish to add, Sir, that this Association has so far been functioning mainly depending on the annual subscriptions collected from its members. This subscribed sum was generally inadequate to meet all the expenses of the Association and therefore had to be supplemented with token donations from members of the teaching staff of the University. This was brought to the notice of our President at the inaugural function and I am very happy to announce that with the customary farsight and generosity the University authorities have kindly sanctioned an annual grant of Rs. 250/- to enable the Association to continue its activities unhampered and at optimum level of efficiency. It is also a matter for rejoicing that permission has been given to publish a short résumé of the activities of the Association in Sections A and B of the Journal of the University. It is now my pleasant duty to record in this connection the high sense of gratitude of the members of the Association to our esteemed Vice-Chancellor not only for sympathetically considering and subsequently sanctioning our aforesaid requests but also for the keen and sincere interest that he

has been evincing all along in the welfare of the Association. I owe a deep debt of gratitude to our Vice-President for all the selfless and invaluable services that he has rendered for the cause of the Association, but for whose initiative and enthusiasm, we would not have achieved as much as we have done this academic year. My thanks are next due to the Committee members without whose help and co-operation, I would not have succeeded in conducting the activities of the Association in a satisfactory manner. I am also grateful to the Registrar of the University for all that he has done for the Association and to the members of the teaching staff, for their liberal cntribution, and also to the members of the Association for taking keen interest in each and every function of the Association.

University Departmental
Buildings, Madras-5.

R. M. ARUNACHALLAM,
Secretary.

Résumé

DEPARTMENT OF ANTHROPOLOGY

University of Madras

1. Number of research students enrolled and Degrees for which they work :

   2 students for M.Litt., and one for Ph.D. Degrees.

2. Titles of theses, etc. :

   During 1958-59, two non-stipendiary research scholars and one Government of India Research Scholar continued to work under the guidance and supervision of Dr. U. R. Ehrenfels, Head of the Department. They worked on the following subjects :

   1. Mrs. Shirley Berry Isenberg, U.S.A.,
      "Changes in Occupation & Status of Women in Madras".
   2. Miss C. R. Rajalakshmi,
      "The Position of Widows in Hindu Societies".
   3. Mr. A. Govindachari,
      "The Finger and Palmer Prints of South Indian Tribes".

The Government of India Senior Research Scholar completed his tenure of three years and submitted his final report of work done by him. Another non-stipendiary research student is now engaged in collecting data for her work, "The Position of Widows in Hindu Societies" and is nearing completion for the submission to the University for the M.Litt. Degree. One of the above non-stipendiary research scholars, Mrs. Shirley Berry Isenberg of U.S.A., now completed her research work, "Changes in Occupation and Status of Women in Madras State", and will be submitting her thesis in August 1959 for the M.Litt. Degree of this University.

3. Full Titles of Published Papers during 1958-1959 :

   (a) Dr. U. R. Ehrenfels, Head of the Dept.

1. Social Education for Tribals in India, "The Govt. Bulletin of the Tribal Research Institute, Chindwara, M.P. (in the press).
2. Kadar of Cochin, East Africa, West Africa, South Africa, North Africa and Khasi, "Telugu Encyclopaedia," Madras (in the press).

3. Example and Responsibility, "Indian Journal of Social Work", Bombay, 1958.
4. Bilineal Clan Succession in East Africa, "Man", The Royal Anthropological Institute, London (in the press).
5. Northerners *vs.* Southerners, "Illustrated Weekly of India", Bombay, 1959.
6. Anthropology & Traditional Cultures, "Bulletin of the Institute of Traditional Cultures", UNESCO, Madras University Bldgs., Madras, (in the press).
7. Contributed one article to the "Centenary Volume" to be published in honour of his (Dr. Ehrenfels) father late Professor Christian Baron von Ehrenfels.
8. The Cultural Needs of Indians in East Africa, "The Indo-Asian Cultures", Indian Council for Cultural Relations, New Delhi.

(b) Sri M. S. Gopalakrishnan, Lecturer in the Dept.

1. A Nambudiri Saint of Kerala, Madras University Journal, Jan. 1958.
2. A Day inside a Temple in Kerala, Madras University Journal, July 1958.
3. Ifugao, Marriage, Cultural Levels, Navigation, Dress & Ornaments, Law and Government, Telugu Encyclopaedia, Madras, (in the press).
4. Veddas of Ceylon, Tamil Encyclopaedia, University Buildings, Madras (in the press).
5. Periya Palayam Goddess — A paper contributed to the Madras University Journal (in the press).

4. Attending International Conferences, etc.:

During 1958 Dr. U. R. Baron von Ehrenfels, Head of the Department, was the recipient of a scholarship award of 10,000 Sw. Cro. offered by the Elin Wăgner Foundation, Stockholm (Sweden), for research work on "Matrilineal Societies in East Africa". In this connection Dr. Ehrenfels left for Africa on study leave for about a year from 5th October. During 1958 he was in Africa and conducted competitive studies of matrilineal African societies and of the changing position of women in both, African as well as Indian communities in British East Africa.

Dr. Ehrenfels, Head of the Department, attended and took part in the discussion of the UNESCO International Seminar on "The

Preservation and Development of Traditional Cultures of South East Asia" held under the auspices of the University of Madras, in November 1958.

He attended the 40th Sesssion of the Indian Science Congress held at Delhi in January 1959 as a delegate of the Madras University and read a paper on: "Bilateral Clan Succession in British East Africa" and took part in the discussion. In addition to this he has also led the Symposium on "Cultural Integration of India."

He also led the Symposium arranged by the Institute of Traditional Cultures, UNESCO, Madras University Buildings, Madras, and also read a paper on: "Anthropology and Traditional Cultures".

DEPARTMENT OF ARABIC, PERSIAN AND URDU

Number of Research students enrolled and degrees for which they work:	One. For M.Litt.
Title of Thesis work in progress:	The Development of Urdu Literature in Tamilnad.

DEPARTMENT OF BIOCHEMISTRY

1. Staff:
   Dr. P. S. Sarma, M.Sc., Ph.D. (Wisconsin), F.R.I.C., F.A.Sc., Professor.
   Dr. E. R. B. Shanmugasundaram, M.A., B.Sc., Ph.D., Senior Lecturer.
   Mr. K. S. V. Sampath Kumar, B.Sc. (Hons.), Research Assistant.

2. Research workers, the nature of their work and the degrees for which they work:

Post doctoral workers	*Nature of work*
1. Dr. T. A. Sundararajan, National Research Fellow.	Biosynthesis of phosphoproteins.
2. Dr. T. K. Sundaram, National Research Fellow.	Metabolism of nicotinic acid and nicotinamide.
3. Dr. K. V. Rajagopalan, Assistant Research Officer, I.C.M.R. Enquiry.	Metabolism of nicotinamide and nicotinic acid.
4. Dr. K. Sivarama Sastry, Senior Scientific Assistant, C.S.I.R. Scheme.	Studies on trace elements.

Submitted for Ph.D.	*Title of thesis*
1. K. S. V. Sampath Kumar	(1) Phosphoproteins
2. E. Raghupathy	(2) Studies on iodoamino acids, iodoproteins and iodopeptides.

Working for Ph.D.

1. V. Venkatasubramaniam.	Interrelationship among trace elements.
2. A. Ramiah	Studies on trace elements.
3. C. V. Pichappa	Microbial Metabolism.
4. P. V. Narasimha Murthy	Biochemistry of thyroid hormone.
5. M. Udyachandar	Studies on sterol and fat metabolism.
6. D. S. R. Sarma	Studies on orotic acid and lipid metabolism.
7. T. S. Raman	Microbial metabolism.
8. P. R. Adiga	Studies on trace elements.

Submitted for M.Sc. degree

1. K. Saroja.	Studies on proteolytic enzymes.

Working for M.Sc. degree

1. T. G. Rajagopalan.	Studies on phosphoproteins.
2. M. A. Mukundan.	Studies on nicotinic acid and other B-vitamins.
3. G. Yeshoda.	Studies on insect biochemistry.

Degrees awarded during the year

1. K. Sivarama Sastri	Ph.D.	Studies on B-vitamins and trace elements.
2. L. Viswanathan	Ph.D.	Studies on strepogenin and other growth factors.
3. A. Thangamani	Ph.D.	Studies on ascorbic acid.

3. *Papers published*:

1. Studies on the enzymic digestion of some proteins and their iododerivatives.
   E. Raghupathy, N. R. Moudgal and P. S. Sarma, *Enzymologia*, **19**, 303, 1958.
2. Studies on goitrogenic agents in food. III. Goitrogenic action of some glycosides isolated from edible nuts.
   N. R. Moudgal, E. Raghupahy and P. S. Sarma, *J. Nutrition*, **66**, 291, 1958.
3. Influence of some iodoaminoacids and iodoproteins on the growth of *Corcyra cephalonica St.*

N. R. Moudgal, E. R. Raghupathy and P. S. Sarma, *Nature,* **181,** 1655, 1958.

4. Further studies on the influence of thyroxine and triiodo thyronine on the growth and metabolic processes in the rice moth larvae, *Corcyra cephalonica St.*
N. R. Moudgal, E. Raghupathy and P. S. Sarma, *Cur. Sci.* **27,** 483, 1958.

5. Effect of thyroid imbalance on the detoxication of benzoic acid in the rat.
N. R. Moudgal, E. Raghupathy and P. S. Sarma, *Endocrinology,* **64,** 326, 1959.

6. Studies on 'Iodothyrins'.
E. Raghupathy, N. R. Moudgal, P. V. Narasimha Murthy and P. S. Sarma. Paper presented at the symposium on 'Proteins' held at New Delhi (in January '59 by the Society of Biological Chemists, India).

7. Role of cation in the dephosphorylation of phosphoproteins by alkali.
T. A. Sundararajan, K. S. V. Sampath Kumar and P. S. Sarma. *Biochim Biophy. Acta,* **28,** 148, 1958.

8. Improved method for the preparation of dephosphorized casein.
K. S. V. Sampath Kumar, T. A. Sundararajan and P. S. Sarma, *J. Sci. Ind. Res.* **17C,** 115, 1958.

9. Some properties of protein phosphokinase from rabbit mammary gland.
T. A. Sundararajan, K. S. V. Sampathkumar and P. S. Sarma, *Biochim. Biophys. Acta,* **29,** 449, 1958.

10. Biosynthesis of phosphoprotein in the frog.
K. S. V. Sampath Kumar, T. A. Sundararajan and P. S. Sarma, *Proc. Soc. Exptl. Biol. Med.* **99,** 539, 1958.

11. Action of proteolytic enzymes on dephosphorized casein.
T. A. Sundararajan and P. S. Sarma, *Enzymologia,* **20,** 57, 1958.

12. N-Terminal Amino acids of some phosphoproteins.
K. S. V. Sampath Kumar, T. G. Rajagopal, T. A. Sundararajan and P. S. Sarma.
Papers presented at the symposium on 'Proteins' held at New Delhi in January 1959 by the Society of Biological Chemists, India.

13. Substrate specificity of phosphoprotein phosphotase from ox spleen.
T. A. Sundararajan and P. S. Sarma, *Biochem. J.*, **71**, 539, 1959.

14. Metabolism of nicotinamide and nicotinic acid in *Neurospora crassa.*
T. K. Sundaram, K. V. Rajagopan and P. S. Sarma, *Biochem. J.*, **70**, 196, 1958.

15. Biological Deamidation of Nicotinamide in Vertebrates.
K. V. Rajagopal, T. K. Sundaram and P. S. Sarma, *Nature* **182**, 51, 1958.

16. Effect of sulfanilamide on formation of sterols in *Saccharomyces cerevisiae* and *Neurospora crassa.*
K. V. Rajagopal and P. S. Sarma, *Biochem. J.* **69**, 53, 1958.

17. Deamidation of nicotinamide and its relation to biosynthesis of pyridine nucleotides.
K. V. Rajagopal, T. K. Sundaram and P. S. Sarma.
Paper presented at the symposium on 'Vitamins' held at Mysore in October 1958 by the Society of Biological Chemists, India.

18. Absence of vitamin B_{12} and methylation system in *Corcyra cephalonica St.*
T. K. Sundaram and P. S. Sarma, *J.Sci. Ind. Res.*, **17C**, 16, 1958.

19. Nonessentiality of vitamin B_1 for the biosynthesis of nicotinic acid from tryptophane.
U. Sitarama Acharya, T. K. Sundaram and P. S. Sarma. *J. Sci. Indi. Res.* **17C**, 26, 1958.

20. Effect of copper on growth and catalase levels of *Corcyra cephalonica St.* in zinc toxicity
K. Sivaramasastry and P. S. Sarma, *Nature*, **182**, 532, 1958.

21. Influence of molybdenum toxicity on sulphur amino acid metabolism in *Neurospora crassa.*
K. Sivaramasastry, A. Ramaiah and P. S. Sarma. *Biochim. Biophys., Acta.* **30**, 438, 1958.

22. Studies on zinc toxicity in the larvae of the rice moth, *Corcyra cephalonica St.*
K. Sivaramasastry, R. Radhakrishnamurthy and P. S. Sarma. *Biochem. J.*, **69**, 425, 1958.

23. Biosynthesis of riboflavin in *Eremothecium ashbyii* R. Radhakrishnamurthy, and P. S. Sarma, J.Sci. Ind. Res., **17C**, 125, 1958.

24. Studies on insect Biochemistry. Part I. Water-Insoluble growth factors in yeast.
R. Sivaramakrishnan and P. S. Sarma, *J. Sci. Ind. Res.* **17C**, 4, 1958.

25. Preservation of Neera with Paludrine — P. S. Sarma.
Paper presented at the Science Congress at New Delhi in January 1959.

4. *Other activities*

1. Three special enquiries are undertaken during the year—two of which are sponsored by the Council of Scientific and Industrial Research and one by the Indian Council of Medical Research.
    1. C.S.I.R. Enquiry, Preservation of Neera.
    2. C.S.I.R. Enquiry, Metabolism of trace elements and phosphoproteins.
    3. I.C.M.R. Enquiry, Studies on carbohydrate, fat and vitamin metabolism.
2. A grant of $ 10,000 was made to the Department by the Rockefeller Foundation, New York, U.S.A., for carrying out advanced fundamental research in biochemistry.
3. Dr. E. R. B. Shanmugasundaram, Senior Lecturer, had a course of training for 1 year in Biochemical genetics at the University of Glasgow, under Colombo plan. He also attended a course at Harwell (radio-chemical center) on the use of radioactive isotopes.
4. Dr. T. K. Sundaram, National Research Fellow, is proceeding to U.S.A., for post-doctoral studies at the University of California, Berkeley.
5. Dr. N. R. Moudgal, Senior Research Assistant in the C.S.I.R. Scheme left for U.S.A. on a post-doctoral fellowship to carry out research under Prof. C. H. Li, Director, Hormone Research Laboratory, University of California, Berkeley.

DEPARTMENT OF BOTANY

1. *Staff* :

Professor T. S. Sadasivan, D.Sc. (Lond.)., F.N.I., F.A.Sc. Professor and Director.
Dr. T. V. Desikachary, M.Sc., Ph.D., F.A.Sc., Reader in Botany.
Dr. (Miss) L. Saraswathi Devi, M.A., Ph.D., Senior Lecturer.
Mr. N. Sethunathan, M.Sc., Research Assistant.

2. *Research Workers* :

The nature of their work and the degrees for which they work.

(a) *Post Doctoral Workers* :	*Nature of Work* :
1. Dr. S. Suryanarayanan, Research Fellow, N.I.S. (India)	Studies on blast disease of rice.
2. Dr. R. S. Badami, Senior Research Fellow, N.I.S. (India)	Plant Virus Serology.
3. Dr. (Miss) C. B. Sulochana, Assistant Research Officer, Lathyrism Enquiry, I.C.M.R.	Studies on Etiology of Lathyrism.
4. Dr. M. Lakshmanan, Officer, I.C.A.R. Scheme, 'Bio-assay and other techniques'	Bio-assay and other techniques in the study of Plant Diseases.
5. Dr. D. Subramanian, I.C.I. Research Fellow, N.I.S., (India)	Fungal Enzymes and Plant Wilts.
6. Dr. (Miss) K. Bhuvaneswari	Rhizosphere in relation to Root Exudates.

(b) *Submitted for Ph.D.*	*Titles of Theses*
1. Miss. R. Andal	Studies on Foot-Rot Disease of Rice.
2. Mr. V. Durai Raj	Studies on Fruit-Rot of Chillies.

(c) *Working for Ph.D.*	*Problem*
1. Miss. Padmabhai Pushpanathan	Studies on the Helminthosporioses of Crop Plants.
2. Mr. T. K. Ramachandra Reddi	Studies on soil fungi.
3. Mr. V. T. John	Studies on plant viroses with special reference to Host Physiology.
4. Miss. S. Malini	Heavy metals and host-parasite relationships in plant wilts.
5. Miss. M. Lakshmi Kumari	Rhizosphere microfloras and host-parasite relationships.
6. Mr. R. Narasimhan	Studies in the genus *Sclerotium*.
7. Mr. S. Subramanian	Studies on the wilt of pigeon pea.
8. Mr. A. Ramadasan	Physiology of virus-infected plants.
9. Mr. N. Rajagopalan	Studies on Root nodule bacteria.

Working for M.Sc. Degree :

1. Mr. K. Rajagopalan — Studies on Foot Rot of paddy.

Degrees Awarded during the year 1958-59 :

1. N. S. Subba Rao — *Ph.D.* Studies in the genus Fusarium with special reference to toxicology.
2. C. B. Sulochana — *Ph.D.* Soil conditions and wilt diseases in plants. Studies on root exudates and rhizosphere microflora in relation to fungal wilts.
3. K. Bhuvaneswari — *Ph.D.* Studies on the rhizosphere microflora of crop plants.
4. Vimala Sivapalan — *M.Sc.* Studies on *Sclerotium rolfsii.*
5. N. Sethunathan — *M.Sc.* Studies on *Sclerotium oryzae.*

List of Papers published during the year 1958-1959:

1. Hyphomycetes, V., C. V. Subramanian, *J. Indian bot. Soc.*, **37** : 47-64, 1958.
2. The Physiology of Host-Parasite relationship in the *Fusarium* wilt of cotton. Part II. Pectin Methyl Esterase formation by *Fusarium vasinfectum* Atk. K. Lakshminarayanan. *Proc. Indian Acad. Sci.* B **47**: 78-86, 1958.
3. Problems and techniques involved in trace element essentiality studies with fungi. L. Saraswathi Devi. *Proc. Indian. Acad. Sci.* B **48**: 96-108, 1958.
4. The Physiology of Host-Parasite relationship in the *Fusarium* wilt of cotton. III. Distribution and derangement of free amino acids. K. Lakshminarayanan. *Proc. Indian Acad. Sci.* B **48**: 115-123, 1958.
5. Taxonomy of fungi. C. V. Subramanian. *Mem. Indian bot. Soc.* **I**: 44-51, 1958.
6. Taxonomy of algae. T. V. Desikachary. *Ibid.* **I**: 52-62, 1958.
7. Spectrochemical methods. T. S. Sadasivan. *Ibid.* **I**: 77-81, 1958.
8. Bio-assay—The *Aspergillus niger* technique for heavy metals. L. Saraswathi-Devi. *Ibid.* **I**: 82-86, 1958.
9. Role of toxins in vascular wilts. D. Subramanian. *Ibid.* **I**: 87-90, 1958.

10. Phytotoxaemia. N. S. Subba Rao. *Ibid.* **I**: 91-93, 1958.

11. Root exudates. C. B. Sulochana. *Ibid.* **I**: 94-96, 1958.

12. Root exudates in relation to Rhizosphere effect. K. Bhuvaneswari. *Ibid.* **I**: 98-101, 1958.

13. Cellulose decomposition. C. S. Venkataram. *Ibid.*, **I**: 102-106, 1958.

14. Thiamine, its intermediates and growth of *Piricularia* spp. and *Sclerotium oryzae*. S. Suryanarayanan. *Phytopath. Z.* **33**: 341-348, 1958.

15. Role of Nitrogen in host susceptibility to *Piricularia oryzae*. Cav. S. Suryanarayanan. *Curr. Sci.* **27**: 447-448, 1958.

16. Growth factor requirements of *Piricularia* spp. and *Sclerotium oryzae*. S. Suryanarayanan. *Proc. Indian Acad. Sci.* **48**: 154-188, 1958.

17. Notes on Indian Red Algae. I. M. S. Balakrishnan. *J. Indian bot. Soc.* **37**: 138-146, 1958.

18. On the red alga *Corynomorpha prismatica*. M. S. Balakrishnan. *Curr. Sci.* **27**: 307-309, 1958.

19. The problem of Blast disease of Rice. T. S. Sadasivan. *Curr. Sci.*, **28**: 10-11, 1959.

20. The problem of Blast disease of Rice. T. S. Sadasivan. *Proc. Indian Acad. Sci.* B **49**: 1-6, 1959.

21. Rhizosphere microflora of Pteridophytes. T. K. Ramachandra Reddy. *Curr. Sci.* **28**: 113-114, 1959.

22. Production of growth promoting substances by Fusaria and their action on root elongation in *Oryza sativa* L. C. S. Venkataram. *Proc. Indian Acad. Sci.* B **49**: 167-182, 1959.

23. Cellulolytic activity and fungal nutrition with special reference to decomposition of bacterial cellulose by *Fusarium culmorum*. C. S. Venkataram. *Phytopath. Z.* **35**: 122-134, 1959.

24. A technique for studying pH changes produced by celluloytic fungi in cellulose substrate. C. S. Venkataram. *Curr. Sci.* **28**: 115-116, 1959.

25. Mechanism of resistance of Paddy (*Oryza satica* L.) to *Piricularia oryzae* Cav. I. General considerations. S. Suryanarayanan. *Proc. Nat. Inst. Sci. India* B **24**: 285-92, 1959.

26. Root and nodule development in *Dolichos lablab* L. infected with Dolichos enation Mosaic virus. V. T. John. *Curr. Sci.* 28: 211, 1959.

27. A systematic account of the South Indian Characeae. V. S. Sundaralingam. *Proc. Indian Acad. Sci.* B 49: 7-51, 1959.

28. An agar-cup method for detection of microbiological oxidation of iron in soil. M. Lakshmi-Kumari. *Curr. Sci.* 28: 296-297, 1959.

List of Papers in Press:

1. Foliar sprays of urea and Rhizosphere microflora of rice. T. K. Ramachandra Reddy.
2. Carbohydrate and obligate parasitism. T. S. Sadasivan.
3. Carbohydrate and faculative parasite. C. V. Subramanian.
4. Rambling thoughts in the carbohydrate metabolism of phytopathogenic fungi. S. Suryanarayanan.
5. Carbohydrate metabolism and host-parasite relationship. D. Subramanian.
6. Some aspects of carbohydrate metabolism in Algae. T. V. Desikachari.
7. Respiratory changes in *Fusarium*-infected cotton. M. Lakshmanan.

Other Activities:

1. Two special enquiries are undertaken during the year, one of which is sponsored by the Indian Council of Medical Research and one by Indian Council of Agricultural Research.
   (i) I.C.M.R. — Lathyrism enquiry.
   (ii) I.C.M.R. — Bio-assay and other Techniques.
2. Dr. N. S. Subba Rao, proceeded to Canada on a post doctoral fellowship of National Research Council, Canada.
3. Dr. C. V. Subramanian, former Reader in Botany, is now appointed Professor of Plant Pathology, Indian Agricultural Research Institute, New Delhi.
4. Professor T. S. Sadasivan, led two symposia at the 45th and 46th sessions of the Indian Science Congress at Madras and Delhi respectively. Some other members of the department also took part in the same.

5. Professor T. S. Sadasivan, Director, University Botany Laboratory was elected Vice-President of the Phytopathological section of the IX International Botanical Congress held at Montreal, August, 1959. Prof. T. S. Sadasivan took part in the symposium "Host-parasite Physiology" and presented a paper entitled "*In-vivo* changes in Fusarium wilted cotton". In a round-the-world tour Prof. Sadasivan visited Japan, United States of America, Canada, United Kingdom and Germany. While in Japan Prof. Sadasivan delivered a lecture on 'The cotton wilt problem' at the Nagoya University, summarising the work done at Madras on this problem. In U.S.A. he visited some select centres of research specializing on similar fields as this laboratory and took part in many discussions and seminars. At the Connecticut Agricultrural Experimental Station, Yale University, New Haven, Prof. Sadasivan delivered the Lockwood lecture on 'The problem of the blast disease of rice'. In the last lap of his trip Prof. Sadasivan visited many laboratories at the United Kingdom and Germany. At the University of Halle a lecture was delivered under the presidentship of Prof. Mothes, the subject being 'Rhizosphere exudates and microbial patterns.' The visits to the various institutions all over the world have been very useful in exchanging ideas on the current problems of plant pathology.

DEPARTMENT OF BUSINESS MANAGEMENT 1958-59

This Department — one of the four regional departments (others Bombay, Delhi and Calcutta) to conduct courses in Management Training to the Junior and Middle Management Executives of Business and Industry—came into operation in 1955, on the recommendations of the All India Board of Management Training, a sub-body of All India Council for Technical Education.

Besides the regulars, there are three Research (Part-time) Scholars whose work has been mostly concentrated on :

1. "Operational Research—for better product acceptability".
2. "Communication in Industry".
3. "Sales Promotion Techniques".

The Professor of Business Management G. V. Krishna Rao, M.A., B.L., M.B.A. (Columbia), has acted as Management Consultant to International Labour Organisation in its Study

Seminar held in Rangoon, Burma, Nov.-Dec. 1958 and presented the following papers

1. "Employees, Personnel Management and Staff Training".
2. "Research and Planning".
3. "Tools of Top Management".

The papers have been published by I.L.O. in its Report of "Expanded Programme of Technical Assistance" (Rangoon 1958).

The Professor served on the Indian Management Team of Government of India, which visited U.S.A.—April-May-June 1959—to study the present developments in Management Education and training in U.S. Universities and Industry, and effective utilisation of the experience in the development of Management studies in India. A 100 page Report and Recommendations are submitted to Government of India for approval and implementation.

The Reader in Business Management, R. V. R. Sivagnanam, B.Com., B.L., M.B.A. (Mich.), has chosen the following for his research:

1. "Market Research—Guide to Effective Sales Planning".
2. "Banker—His Changing Role in the Expanding Economy".

DEPARTMENT OF CHEMICAL ENGINEERING
UNIVERSITY OF MADRAS
ALAGAPPA CHETTIAR COLLEGE OF TECHNOLOGY

Number of Research Students enrolled and Degrees for which they work:

Ph.D. Degree: 4 (Four).
M.Sc. Degree: 8 (Eight).

Titles of Theses Work in progress:

1. "Studies in Liquid-liquid Extraction".
2. "Some Problems in Low Energy Physics and Nuclear Structure".
3. "Many-body Problem and Nuclear Structure".
4. "Studies in Industrial Chemical Analysis".
5. "Studies in Vapour Liquid Equilibria".
6. "Mass Transfer Studies in Liquid-liquid Extraction".
7. "Phase Equilibrium Studies in Liquid-liquid Extraction".
8. "Some Studies in Distillation".
9. "Studies in Heat Transfer".

Degrees awarded and titles of those Theses:

1. *Ph.D. Degree:*
   (i) Sri B. Chennakesavan.
   "Studies in Heat Transfer".
   (ii) Sri G. Venkataraman
   "Studies in Liquid-liquid Extraction".
2. *M.Sc. Degree:*
   (i) Sri S. Subramanian
   "Studies on the Properties and Utilisation of South Arcot Lignite".
   (ii) Sri S. Hamsath Ibrahim
   "Study of the Principles and Technique of Electro Analytical Chemistry developed in recent years".

Full Titles of Published Papers (full title and name, volume, year and pagination of Journal) published:

1. Thomas Samuel and Laddha, G. S.: Ternary Systems with Ethylene Glycol. *J. Madras Univ.* B **XXVIII**, Nos. 2 and 3, pages 147-159, 1958.
2. Hamsath Ibrahim, S.: Coulometric Analysis. *Altech*—Volume **VII**, 1957-58, pages 35-51.
3. Ramanujam M.: Vapour Liquid Equilibrium Stills. *Altech*—Volume **VII**, 1957-58, pages 53-69.
4. Subramanian, S. and Madhavan Nair, A. P.: Classification and Grading of South Arcot Lignite. *Altech*—Volume **VII**, 1957-58, pages 31-34.
5. Subramanian, S. and Madhavan Nair, A. P.: Solvent Extraction of South Arcot Lignite. *J. Madras Univ.* B **XXVII**, Nos. 2 and 3, pages 317-326.
6. Hamsath Ibrahim, S. and Madhavan Nair, A. P.: Polarographic Analysis of Standfast Alloy. *Journal of Scientific and Industrial Research*, 1958, Vol. **17-B**, No. 5, page 190-191.

DEPARTMENT OF ECONOMICS

1. No. of research students enrolled and degrees for which they work:

   Four—M.Litt.

2. Titles of theses work in progress:
   (i) Progressive Taxation in India
   (ii) Financing of Industrial Development in India

(iii) Growth of Central Banking in India
(iv) Monetary Policy and Economic Development.

3. Degrees awarded and titles of those theses:
M.Litt—Banking Legislation in India
4. Full titles of published papers: (of Research Students only)
Nil
5. Any other research activities of the staff such as special investigations, attending of International Conferences, etc.

The Professor, besides directing the work of the various research schemes under his guidance, attended the following two International Seminars :

1. Traditional Cultures (UNESCO)
2. Techniques of Social Research (UNESCO).

DEPARTMENT OF INDIAN HISTORY AND ARCHAEOLOGY

Number of Research students and the degrees for which they work:

There were two Research Fellows, four Stipendiary Research students, two probationary Research students who have also been granted stipendiary studentship from August and six non-stipendiary students in the Department.

Of these research workers four were working for the Ph.D. Degree and the rest for the Degree of M.Litt.

Titles of theses work in progress :

1. Muslim contact with South India.
2. Administrative policies of Government of Madras 1800-1865.
3. Lord Clive in Madras. (Thesis submitted in Jan. 59).
4. The History of Tondaimandalam from the Sangam age to the end of the 17th century.
5. Governors of Madras, 1827-1842. (Thesis submitted in Jan. 1959).
6. Humanitarian Ideas in Madras Administration 1800-1851.
7. Sir Charles Trevelyan, Governor of Madras.
8. The Administration of the Governor, Lord George Pigot.
9. The English and the Nawabs of the Karnatic up to 1802.
10. Influence of Home Government on Madras Administration.
11. Eclipse of the Company's Rule in Madras.
12. Poligars.
13. Tirukkalukkunram and its temples.
14. French Pioneers in South India.

15. Buddhist Art in India (A casual student of this Department from America is doing this research).

Degrees awarded:

One former student who submitted her thesis last year for the Ph.D. Degree was declared qualified for it this year.

Works published during the year:

Dr. K. K. Pillay, Professor of Indian History & Archaeology:

i. South Indian History (in Tamil) (Southern Languages Book Trust).
ii. Western influence on the development of Tamil Prose (Tamil Culture).
iii. The Origin and development of the Matriarchal System in Kerala. (Proceedings of the 17th Session of the Indian History Congress.)
iv. The Pudukkottai Plates of Srivellabha and Varatunga- (Proceedings of the 18th Session of the Indian History Congress).

Dr. T. V. Mahalingam, Professor of Archaeology:

i. Two Eastern Ganga Inscriptions at Kanchipuram (Epigraphia Indica).
ii. The Nolamba Pallavas, their Origin (Journal of Indian History).
iii. A Brahmi Inscription from Kunrakkudi (Madras University Journal).
iv. The Accession of Nandivarman II Pallavamalla (Journal of Indian Hitsory).
v. Skandasishya II (Transactions of the Archaeological Society of South India).
vi. Aditya and Vikramaditya (Journal of Indian History).

Dr. M. Arokiaswami: Reader in Indian History:

i. Beschi and his times (The Tamil Annual Colombo).
ii. The Economy of the Sangam Age (Madras University Journal).
iii. The Lottery as a source of Revenue under the East India Company in Madras (Madras University Journal).

Topics on which research is in progress by the staff of the Dept. and the works completed during this Academic Year:

Dr. K. K. Pillay:

i. He completed Part I of the Social History of the Tamils from the early times to the present day.

ii. He took on hand the preparations of the Social History of the Tamils, Part II, and studied the data available in South Indian Inscriptions.

Dr. T. V. Mahalingam :

He completed the work on the Origin and Evolution of Palaeography in South India with special reference to Brahmi Inscriptions in the Tamil country.

Dr. M. Arokiaswami :

He continued collecting material for the work on "Sir Thomas Munro as an Administrator".

Other General Information :

Dr. K. K. Pillay :

i. He delivered a course of two lectures under the Sir Subrahmanya Iyer Endowment on 'Narrinai in its Historical Setting'.

ii. He attended the meeting of the Central Advisory Board of Archaeology held at Hyderabad on 9th October 1958.

iii. He attended the 21st Session of the Indian History Congress and the 34th Session of the Historical Records Commission.

Dr. T. V. Mahalingam :

He attended the Indian Science Congress held at Madras in January 1958 and participated in a Symopisum on 'Facilities for Post-graduate studies and Research in Anthropology and Archaeology in Indian Universities.

DEPARTMENT OF INTERNATIONAL AND CONSTITUTIONAL LAW

1. Number of Research students enrolled: 5.

2. *Titles of the works in progress* :

i. Mr. K. Narayana Rao, Research Fellow :
He has submitted a paper on "The Constitution of the Phillipines," published in the Indian Year Book of International Affairs 1957.

ii. Mr. K. P. Krishna Shetty :
He has written a paper on "the Legal Status of Indian Residents in Ceylon", published in the Indian Year Book of International Affairs, 1958.

iii. Mr. Kelunni Kartha :
He is engaged in research on Fundamental Rights in the Indian Constitution.

iv. Mr. C. Appa Rao :
He has written a paper on "China and the Law of Nations."

v. Mr. V. C. Govindaraj :
He is working on Problems of the History of the Law of Nations in Asia.

The Head of the Department Professor Charles Henry Alexandrowic has published a paper on Dutch—Persian Treaty Relations in the Seventeenth Century. (Indian Year Book of International Affairs 1958.)

The Professor has attended the International Conference of Comparative Law organized by UNESCO. (Rome 1958).

DEPARTMENT OF MALAYALAM

1. No. of research students enrolled & degrees for which they work : Nil.
2. Titles of theses work in progress : Nil.
3. Degrees awarded and titles of those theses : Nil.
4. Full titles of published papers (etc.) : Nil.
5. Any other research activities etc.

Research work is being carried on by the staff of the Department in the following subjects : —

1. Sasta Cult in Kerala.
2. History of Malayalam Language.
3. Studies in Mediaeval Malayalam.

DEPARTMENT OF MATHEMATICS

No. of Research Students : Five; four working for the Ph.D. and one for the M.Sc.

Titles of theses work in Progress: Generalisation of the real number system, Ordered Algebraic Structures, Studies in Lattice theory, Studies in Algebraic Geometry.

Degrees awarded and titles of the theses : Ph.D. to Sri R. Ramachandran on a thesis on 'Generalisations of the Hahn-Banach property'.

Published papers: The Professor has sent a paper 'On demigroup Structures, II' for the Jubilee number of the *Journal of the Indian Mathl. Society*. Reports have been sent by the Professor, Reader and the research students on the talks they gave under the Symposium on 'Ordered Structures' at the Conference of the Indian Mathl. Society, for publication in the *Mathematics Student*. A student has also submitted a paper on 'Recurrence relations for primes' to the *Journal of the Indian Mathl. Society*.

Other activities: The Professor, Reader and three research students presented a symposium on 'Ordered Structures' at the Jubilee Session of the Indian Mathl. Society at Poona in Dec. 58, Jan. 59. Another student presented a paper at the Conference on 'Recurrence relations for primes'.

The Professor continues to review articles for the reviewing journal the *'Zentralblatt für Mathematik'* on topics in Algebra and Topology.

DEPARTMENT OF PHILOSOPHY

1. T. P. Ramachandran
   Title of the thesis: 'The Concept of the Vyavaharika in Advaita Vedanta (for Ph.D. Degree).

   Papers published:
   (1) "From Cause to Ground—a development in Concepts', in Journal of the Madras University, Section A, Vol. XXVIII, No. 2, January 1957, page 205.
   (2) 'The Concept of Sat in Samkara and Ramanuja' Journal of the Madras University, Section A, Vol. XXX, No. 1, July 1958, page 149.
2. Ch. Sambasiva Rao
   Title of the thesis: 'Some aspects of Indian Mysticism with Special Reference to Vemana (for M.Litt.).
3. N. Satyanarayana Chowdari
   Subject: 'A critical study of the works of Tarikonda Venkamamba' (for M.Litt.).
4. Bhaskaran Nambudripad
   Subject: 'Vedanta according to Swami Vivekananda' (for M.Litt.).
5. R. Sundararajan
   Subject: Studies in Modern Empiricism (for M.Litt.).

6. James H. K. Norton
   Subject: 'Reason and Visistadvaita Philosophy with special reference to the Nyaya Karika of Ramanuja (for Ph.D.).
7. Manoraman
   Subject: Mahatma Gandhi and Tolstoy (for M. Litt.).

The Professor attended the third East-west Philosophers' Conference at Hawaii, Honolulu, U.S.A., held during the months June-July 1959 and presented a paper on 'Indian Ethics and Social Practice'.

DEPARTMENT OF PHYSICS

No. of research students enrolled and degrees for which they work.

Titles of theses work in progress:

M.Sc

1. Advanced Techniques in X-ray Crystallography.
2. Crystal Structure of Organic compounds.

Ph.D.

1. Analog Computer Techniques.
2. Structure of Collagen.
3. Optical Studies of Crystalline Materials.
4. Crystal Structure of Organic compounds.
5. X-ray studies of Feather Keratin.
6. Studies on the Anomalous Dispersion of X-rays.
7. Structure of Compounds related to Collagen and Nucleic Acids.
8. Electron — Electron Interaction.

Degrees awarded and titles of those theses: Two Ph.D. Degrees.

Titles:

1. Structure of Amino acids and related compounds.
2. Studies on Techniques of Crystal Structure Analyses.

Full titles of published papers:

1. A new Statistical Test for distinguishing between centrosymmetric and Non-controsymmetric structures — G. N. Ramachandran and R. Srinivasan, *Acta Crystallographica*. (In press).

2. The Structure of L-tyrosine hydrohalides: I—L-tyrosine hydrobromide — R. Srinivasan, *Proc. Ind. Acad. Sci.* (In press).
3. The structure of L-tyrosine hydrohalides: II — L-tyrosine hydrochloride—R. Srinivasan, *Proc. Ind. Acad. Sci.* (In press).
4. An accurate redetermination of the structure of Sodium Chlorate, $NaClO_3$ — C. Aravindakshan, *Z. Kristallogr.* (In press).
5. An accurate redetermination of the structure Potassium Chlorate, $KClO_3$ — C. Aravindakshan, *Z. Kristallogr.* (1958), *III*, 35.
6. Lilavati — A new analog computer for solving linear simultaneous equations and related problems — Part I — G. N. Ramachandran and E. V. Krishnamurthy, *Proc. Ind. Acad. Sci.* A, *XLVIII*, 152, 1958.
7. Same title, Part II — E. V. Krishnamurthy, *Proc. Ind. Acad. Sci.* A, *XLVIII*, 262, 1958.
8. Studies on Collagen:
   III. Oriented Crystallisation of inorganic salts in Collagen —G. K. Ambady, *Proc. Ind. Acad. Sci.* (In press).
9. Studies on Collagen :
   IV. Deposition of inorganic crystallites on Collagen—M. S. Santhanam, *Proc. Ind. Acad. Sci.* (In press).
10. Same Title :
    V. Modification of Collagen by neutral salt solutions — M. S. Santhanam, *Proc. Ind. Acad. Sci.* (In press).
11. Structure and absolute configuration of Lysine hydrochloride monohydrate by the anomalous dispersion method —S. Raman, *Zeitschrift für Kristallographic* (In press).

DEPARTMENT OF PSYCHOLOGY 1958-59

1. Research students enrolled : M.Litt.—2; Ph.D.—4.
2. Degrees awarded : M.Litt. : —
   (1) B. Rama Devi — "Personality Study of Married and Unmarried Teachers."
   (ii) G. Jayalakshmi — "Studies in Psychomotor abilities".

3. Publications:

(i) E. G. Parameswaran — "Age changes in certain aspects of adolescent adjustment", *J. Psychol. Research,* 1958, 2, 106-114.

(ii) M. A. Faroqi — "Co-operation, Competition and Group structure", *J. Psychol. Research* 1958, 2, 60-70.

(iii) G. Jayalakshmi — (a) "Studies in Psychomotor abilities", *J. Psychol. Researches* 1959, 3, 13-20; (b) "Correlation of tests Psychomotor ability with intelligence and motor tests", *J. Psychol. Research* 1959, 3, 78-84.

(iv) B. C. Muthayya — (a) "A study of autocratic democratic attitudes", *J. Psychol. Researches* 1958, 2, 10-17. (b) "A preliminary Design for a level of aspiration test", *J. Psychol. Researches* 1959, 3, 27-32.

(v) P. Rajalakshmi Varma — "Children's fears through Picture Projection", *J. Psychol. Researches,* 1959, 3, 58-65.

4. Theses in Progress:

M.Litt.

(i) Miss Sundari — "Studies in time perception".

(ii) Miss S. Jayalakshmi — "The adjustment of working mothers".

Ph.D.

(i) Mr. E. G. Parameswaran — "Symbolism in Hindu Rituals".

(ii) Miss. P. Rajalakshmi Varma — "Behaviour Problems of Children".

(iii) Mr. B. C. Muthayya — "Studies in level aspiration and its rlation to frustration-reaction".

(vi) Mr. M. A. Faroqi — "Co-operation, Competition and Group Structure".

5. (i) Dr. G. D. Boaz is guiding a research-project on the personality of inmates of penitentiaries with a view to their rehabilitation.

(ii) In January 1959 the Department actively co-operated with the Madras Psychological Society in conducting a Symposium on "Modern Psychology and Indian thought". The Department conducted a Seminar on "Problems in Industrial Psychology" in the beginning of December 1959.

(iii) Batteries of intelligence tests were constructed and standardised for the age groups 11-15, Madras School population.

DEPARTMENT OF SANSKRIT

Number of research students enrolled and Degrees for which they work:

Five University Students.

Two Foreign Students (One from Austria and one from Philippines).

Two for M.Litt.
Two for Ph.D.

Titles of theses work in progress:

1. The Yuktidipika on the Sankhya Karika.
2. Hindu Influences on the Philippines (with special reference to Literature and Allied Arts).
3. The Vasavadatta of Subandhu.
4. Krishnalila Tarangini of Narayana Tirtha.
5. Critical Study and Edition of Dasarupaka and Avaloka and the commentary of Bahurupamisra.
6. The Camatkara Candrika of Visvesvara—Critical Study and Edition.
7. Contribution of Anubhutisvarupacharya.

Other research activities of the staff such as special investigations, attending of International Conferences etc.:

(Dr. V. Raghavan)

In October 1958, the Professor was appointed by the Government of India as a member of an Indological Cultural Delegation for touring USSR. He visited the Oriental Institutes and Departments in USSR, met the Indologists there and studied their work. He visited also the Libraries there, examined their Sanskrit manuscripts, collections and prepared a list of the uncatalogued manuscripts.

He took part in the Seminar of the Traditional Cultures of South-East Asia held in November by the Unesco Institute of

Traditional Cultures, Madras University. He read a paper there and took part in its discussions.

He attended as a University delegate the Kalidasa Conference and Celebrations held under the auspices of the Vikram University, Ujjain; he gave a lecture in the Conference and took part in its discussions and produced the Malavikagnimitra of Kalidasa.

He also attended during the year meetings of the Indology Committee of the Ministry of Scientific Research and Cultural Affairs and the Indian National Commission for Co-operation with Unesco.

(Dr. K. Kunjunni Raja)

The Reader attended the Annual Meeting of the Linguistic Society of India at Poona and read a paper there. Before the Linguistic Circle of Madras he read a paper on 'Indian Influence on Linguistics'.

DEPARTMENT OF TAMIL

There are two Research Students in the Department and they are working on the following subjects for the Ph.D., and M.Litt. Degrees respectively.

1. A study of the literature of Tondaimandalam.
2. Contribution of the European savants to Tamil with special reference to Dr. G. U. Pope.

One Government of India Scholar working on the 'Morphophonemic Analysis of the Tamil Language'.

One Research Fellow worked on 'A study of the minor characters in Kambaramayanam' for M. Litt Degree upto 22-12-1958.

Foreign Student: Mr. Mikhail Sergueevich Andronov, the Research Worker of the Institute of Oriental Studies, Academy of Sciences, the U.S.S.R., has joined the Department on 2-7-1958 and he is working on the 'Modern Tamil Grammar'.

Two Research Students have been awarded the M. Litt, Degree and the titles of these theses are:

1. The Historic Places of the Ancient Tamilakam.
2. A Study of Vocabulary in Silappathikaram.

DEPARTMENT OF ZOOLOGY

Director: Dr. C. P. Gnanamuthu, M.A., D.Sc., F.Z.S.

Number of research students enrolled and Degrees for which they work:

There are 12 research workers in this department of which one is a senior Research Scholar of Forest Research Institute, one a National Research Fellow and three are Government of India Senior Scholars.

Post Doctorol Research

1. Studies on basal metabolism of poikilotherms.
2. Settlement behaviour of larvae of foulers and borers.

Titles of theses work in progress:

The others have registered for the Ph.D. or M.Sc. degrees of the Madras University. The titles of Ph.D. theses in progress are:

1. Studies on Neurosecretion.
2. Studies on Sound reception and production in fishes.
3. Helminth parasitulogical Studies.
4. Studies on Plankton of Madras.
5. Studies on respiration and Chloride regulation in certain crustacean types.
6. Studies on the physiology of wood-boring crustacea.
7. Physiological studies on Mytilus.
8. Studies on wood-boring Pholads.

Titles of M.Sc. Theses in progress

1. Studies on growth rate of fishes.
2. Studies on the oxygen consumption of air breathing fishes.

Degrees awarded and titles of those theses (Ph.D. & M.Sc.):

Theses approved for Ph.D. degree

1. Studies on food and feeding habits of fishes.
2. Physiological studies on Anura of Madras.

Theses approved for M.Sc. degree

1. Polyzoa of Madras-coast.
2. On the wood-boring pholads of Madras.

Titles of Publications during 1958-59:

1. G. Krishnan. Some aspects of cuticular organization of *Streptocephalus. Quart. Jour. Micr. Science,* Oxford, Vol. 99, p. 359.
2. Studies on the copepods of Madras—S. Krishnaswamy, Madras University Publication.
3. Studies on an ascidian of Madras Coast—V. O. Sebastian, Madras University Publication.
4. Studies on Fish-eggs and larvae of Madras coast—P. Vijayaraghavan, Madras University Publication.
5. Daniel, A., The development and metamorphosis of three species of barnacles, *J. Madras University,* B. 28 No. 1, 23-47, 1958.
6. Daniel, A., Settlement of Marine foulers and borers in the Madras harbour in relation to velocity of water currents, *J. Sci. Indust. Res.* 17 C, 1, 18-20, 1958.
7. Mrs. Ruby Daniel. Neurosecretion in crustacea. 1. Neurosecretory organs of the eye stalk of Squilla holoschista, *J. Madras University,* B. 28: 49-63, 1958.
8. Kuthalingam, M.D.K., Studies on post larvae and feeding habits found in the Madras plankton, *J. Madras University,* B. 28: 1-11, 1958.
9. Kuthalingam, M.D.K., Food and feeding habits of some young silver bellies, *J. Madras University,* B. 28: 13-22, 1958.
10. Cherian, A.G., Respiratory movements in the frog *Acta Physiol. Pharmacol,* Neerl, Amsterdam, Vol. 7, p. 420-424 (1958).
11. Daniel, A., A New barnacle, *Balanus* (*Semi balanus*) *Madrasensis* nc. sp. from lshing craft. off Madras *Ann. Mag. Nat Hist.,* London, 1958.
12. Daniel, A.. One Platylepas indicus n.sp. a new barnacle from the Madras coast. *Ann. Mag. Nat. Hist.,* London, 1959.
13. Daniel, A. Notes on the distribution and seasonal variation of marine wood-borers of the Madras area, *J. Madras University,* B. 1958.

14. Daniel, A. A review of the sub-genus Megabalanus. *Ann. Mag. Nat. Hist.,* London. (In press).

15. Krishnan, G. Histochemical observations on the egg capsules of *chiloscyllium. Biol. Bulletin,* U.S.A.

16. Kotteil. Anna, J. Holotrichons ciliates from Madras, *J. Madras University,* B. **29**: 1959.

17. Sita Anantaraman—Tetra phyllidean larva from a marine copepod *Eucalanus psend attenuatus* (Sewell) *J. Zool. Soc. India.* Metacercariae from ctenophore, *Pleurobrachia* globosa (Moser) *Nature.*

18. Sita Anantaraman — Allocreadioidia in the plankton ctenophore, *Pleurobrachia globosa* Moser, from the Madras coast. *Nature,* 1959: 1407-1408.

19. Mrs. Ruby Daniel, A new siphonophore *Lensie apedicellata* from Madras. *Ann. Mag. Nat. Hist.,* London, 1958.

20. Dorai Raj, B.S. The lateral line system and sound perception in cat fish, *Proc. Zool. Soc.,* London, 1958.

21. Srinivasan, V.V. Two species of wood-boring pholads of Madras. *Proc. Ind. Acad. Sci.,* 1959.

RESEARCH ACTIVITIES OF THE FORMER MEMBERS

Research Activities of the former members of the Madras University Research Scholars Association:

Sri S. Balaram, B.E., M.Sc., A.M.I.E.

1950 : Research student, Engineering College, Guindy. Subject of Research : "Antennas—Special Types." (Circular Antennas.)

1955 : Awarded M.Sc. Degree.

Publications: 1. Circular Arc Antennas. *Indian Journal of Physics* XXX 8. 1956. 2. Terminated Circular Loop Aerial. Electronic and Radio Engineer 34. 8. 1957.

Present Occupation : Technical Officer, Madras Air Port.

Sri T. K. Govindan, M.Sc.

1954-57 : Research student, Organic Chemistry Department for M.Sc.

Present Occupation : Research Assistant (Chemistry). Central Fisheries. Technological Research Station (Processing Wing), Ernakulam.

Sri K. V. Raman, M.A., M.Litt.

1954-56 : Research student, Department of Indian History and Archaeology for M.Litt. Subject of Research : The Early History of the Madras Region upto 1650 A.D.

Publications : Several publications have appeared, the latest findings being in "Indian Archaeology, 1958".

Present Occupation : Exploration Section, Department of Archaeology, Government of India, Madurai. Engaged in conducting a detailed survey of antiquarian remains in Madurai District.

Dr. H. G. Narahari, M.A., M.Litt., Ph.D.

1939-41 : Research student, Sanskrit Department for M.L.H. Subject of Research : "Atman in Pre-Upanishadic Vedic Literature."

1943 : M. Litt. Degree was awarded.

1944-45 : Research Fellow, Sanskrit Department.

1958: Ph.D. Degree awarded. Subject of Research : "Karma and Rebirth".

Present Occupation : Sub-Editor, Sanskrit Dictionary Department, Deccan College Research Institute, Poona-6.

Dr. K. Narayanan, M.Sc., Ph.D.

1954 : Awarded M.Sc. Degree. Subject of Research : "Geology of the Magnesite Region, Salem".

1957 : Awarded Ph.D. Degree. Subject of Research : "Structure and Petrology of the Malavalli-Malagur Region".

Present Occupation : Geologist, Oil and Natural Gas Commission, Government of India, Dehra Dun.

Sri K. V. Natarajan, M.A., M.Litt., I.A.S.

1953-55 : Research student. Economics Department, for M.Litt. Subject of Research : "The Economic and Financial Condition of the Residuary State of Madras."

1957 : Awarded M.Litt. Degree. Recruited to the Indian Administrative Service in 1956.

Present Occupation : Sub-Collector, Rajamundry.

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